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C. E. Pellington

DIPHTHERIA

Its Nature and Treatment

BY

C. E. BILLINGTON, M.D.

AND

INTUBATION IN CROUP

AND OTHER

ACUTE AND CHRONIC FORMS OF STENOSIS
OF THE LARYNX

BY

JOSEPH O'DWYER, M.D.

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PREFACE.

I HAVE been emboldened to offer the present work to the Profession by the many gratifying assurances which I have received that my previous writings, which appeared in 1876 and at several subsequent times, have been of service to some. Those writings consisted mainly in statements of my own clinical observations and experience. My chief motive in adding the present one has been a desire to express my views on various important points somewhat more fully than was possible in them, and in connection with related facts in the history, the etiology, and the pathology of the disease, and recent advances in its therapeutics.

To have made this an exhaustive treatise would have been impossible, in view of the great variety of aspects which have been assumed by the disease and its complications in occasional epidemics and individual cases, the wide diversity of the views which have been entertained as to its pathology, and of agents and methods which have been employed in its treatment, the resulting vastness of the literature relating to it, and the limitations of the time and space at my disposal. I have, however, endeavored to present a clear and succinct statement of those facts in existing knowledge which are most essential to the formation of an intelligent opinion as to its nature, and of those therapeutical principles and details, the comprehension and application of which will, as I believe, enable the physician to treat it most successfully.

It affords me much pleasure that Dr. O'Dwyer has kindly consented to treat, in this connection, of that very important addition made by him to our therapeutical resources in dealing with the most distressing and fatal form of diphtheria,—intubation of the larynx.

C. E. BILLINGTON.

NEW YORK, April 15, 1889.

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DIPHTHERIA;

ITS NATURE AND TREATMENT.

CHAPTER I.

DEFINITION AND HISTORY.

DIPHTHERIA is a specific disease which occurs sporadically, endemically and epidemically, and is contagious and infectious, its essential characteristic being an inflammation of mucous membranes, or of the surface of wounds and the adjoining integument, which tends, by cellular proliferation and degeneration and by fibrinous exudation, to the formation of a false membrane, and also to the production of a poison which, when absorbed into the circulation, causes morbid changes in the blood and in various organs of the body.

The name diphtheria was first suggested by Bretonneau, who in his earlier publications employed the term diphtherite, derived from the Greek διφθερα, a membrane, the termination ite (ιτης) signifying inflammation, and the compound word thus admirably describing the "specific phlegmasia" which constitutes the local affection; but in his fifth memoir he adopted instead from Trousseau the name diphthérie, which, without the limiting suffix, more fitly designates the entire disease with its train of local and constitutional phenomena. The equivalent name, diphtheria, was thence adopted by Dr. W. Farr, Register General of England, and has since been universally employed by writers in the English language.

Although this name and much of the more exact knowledge of the disease which has accompanied and followed its introduction are of recent origin, there is abundant evidence that the malady itself has prevailed widely among mankind since the most ancient times. In the sixth century B.C. or thereabouts, D'havantare, an Indian physician, in his "System of Medicine," written in Sanskrit, described the symptoms of an incurable disease called "closing of the throat," and "arising from phlegm combined with blood," which could hardly have been other than diphtheria.[1] The assertion, which has been made by some, that the disease is referred to in the Hippocratic writings,[2] rests on very inconclusive evidence. Asclepiades, in the first century B.C., is said to have performed laryngotomy. Aretæus of Cappadocia, in the first century A.D., gives a graphic and unmistakable description of faucial and laryngeal diphtheria under the names ulcera Ægyptiaca and ulcera Syriaca, which are significant of its wide prevalence. He says that "some ulcers on the tonsils are mild and others are pestilential and deadly." The latter are "extensive, deep, putrid and coated with white, livid or black concretions." He then describes the development and extension of this form of the disease in the throat and the mouth and as a phlegmon on the neck, and its fatal result in "not many days," and adds, "But if this malady invades the chest through the windpipe, it causes suffocation on the same day." He then vividly depicts the symptoms and the struggles which are too often witnessed in the later stages of a fatal case of diphtheritic croup and completes the nosological picture by adding, "Children up to the age of puberty are chiefly affected by this disease."[3] Galen probably referred to diphtheria when he mentioned the expectoration of false membrane from the pharynx and the air-passages.[1] Cœlius Aurelianus in the third century depicted the symptoms of diphtheritic laryngitis and also mentioned the imperfect articulation and the regurgitation of liquids through the nose in swallowing, which result from diphtheritic faucial paralysis.[2] Aetius of Amida in the fifth century described a disease of children, in which the whitish and grayish faucial appearances, the dysphagia, the suffocation, the characteristic symptoms of resulting palatal paralysis, sudden death after apparent recovery, and intolerance of too harsh local treatment form a complete clinical picture of diphtheria.[3] The probability, from some passages in the historians, that severe epidemics of this disease may have occurred in antiquity, of which we have no record by medical writers, is illustrated by Bretonneau (second memoir) in the instance that Macrobius in the year 380 A.D. speaks, according to Julius Modestus, of sacrifices which were instituted in honor of a heathen goddess, "ut populus Romanus morbo qui Angina dicitur, promisso voto, sit liberatus."

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[1] Quoted in "Diphtheria, its Nature and Treatment," by Morell Mackenzie, M.D., p. 14.

[2] Hippocrates: "de Epidemicis," lib. v. cap. iv., and "de Dentitione."

[3] Aretaeus: "De Causis et Signis Acutorum Morborum," lib. 1 cap. 9.

For an interval of more than a thousand years, which constituted the "Dark Ages," there is no distinct record of the disease, probably not from its non-occurrence, but from a lack of competent observers. It is with good reason supposed that some of the "plagues" of the Middle Ages may have been epidemics of diphtheria. Among these were the pest called "esquinancie," a form of angina maligna mentioned in the chronicle of St. Denis for the year 580, and a destructive "pestilentia faucium" at Rome in 856, and another in 1004 recorded by Baronius, and a fatal "cynanche" in the Byzantine empire in 1037 recorded by Cedrenus, and an angina which carried off many children in England in 1389, referred to by Short.[4]

In the sixteenth century records of the occurrence of epidemics of diphtheria begin rapidly to multiply. Among these an epidemic in Holland in 1557 was described by Peter Forest[1] as an "angina maligna contagiosa," rapidly fatal by strangulation, and another in 1564 and 1576 mentioned by Van Wier[2] as an "angina maligna," particularly common among children and fatal in from one to seven days; others occurred in the Rhenish provinces and in North Germany, and one in Naples and Sicily. An epidemic in Paris in 1576 was described by Baillou,[3] who mentioned false membrane as observed in an autopsy: "Pituita lenta contumax quæ instar membranæ cujusdam arteriæ asperæ erat obtenta."

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[1] "De Locis Affectis," lib. 1. cap. 9.

[2] "De Acutis Morbis," lib. iii., cap. 2 et cap. iv.

[3] Petrabibl. Sermo viii., cap. 46.

[4] Cited by Hirsch, Geog. and Hist. Pathol., vol. iii.

In Spain a great epidemic, or succession of epidemics, of angina maligna, there known under the popular name of garrotillo, raged from 1583 to 1618, and was well described by a number of medical writers. Beginning in Seville in the former year, it reached its widest diffusion over the country about 1610, and in 1613 the mortality was so frightful that that year has since borne the name of "anno de los garrotillos." Among the best descriptions of the disease were that of Villa Real,[4] who minutely described false membrane as seen by him, not only in many cases during life, but also in autopsies; that of Herrera,[5] who also observed diphtheritic false membrane in autopsies, and described diphtheria of the skin and of wounds; that of Mercado,[6] physician to Philip II. and Philip III., who noted the slight degree of fever present in some very grave cases, described diphtheritic cervical adenitis, and mentioned an instance of a child communicating the disease to its father by biting his finger; and of Heredia,[1] physician to Philip IV., who distinguished the two forms of the disease, the suffocative and the asthenic, observed paralysis of the palate, the pharynx and the limbs, believed in a secondary infection by the resorption of morbid products, and recommended for its prevention the early employment of cauterization.

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[1] "Observat. et Curat. Medic." lib. vi., observ. ii., schol. Lugd. Bat., 1591.

[2] Van Wier: Observat. lib. i, sec. 3.

[3] Epidemiorum, lib. ii., Genev. 1762.

[4] Villa Real: "De Signis Causis, Essentia, Prognostico et Curatione Morbi Suffocantis," Compluti 1611.

[5] "De Essentia, Causis, Notis, Presagio, Curatione et Precautione Morbi Suffocantis Garrotillo Hispane Appellati," auctore Doctore Herrera, Matriti, 1615.

[6] Consult. med. lib. cons. xiv., in opp. Frankf. 1620.

An epidemic in Portugal in 1626 is described by Barbosa.[2]

In Italy malignant sore throat, having been prevalent in Mantua and Lombardy in 1610,[3] broke out in the city of Naples in 1617, gradually overran the kingdom of the Two Sicilies and the States of the Church, and prevailed in various epidemics and recurrences in many parts of Italy until 1650. Among the accounts of these epidemics are that of Sgambatus,[4] Carnevale,[5] Aetius Cletus,[6] who vividly described not only pseudo-membrane in the fauces, but the gangrenous, the laryngeal, the toxæmic, the asthenic, and the nasal forms of the disease, and also the protracted debility and the paralysis of the vocal organs of those who recovered; and Severino,[7] who described diphtheritic membrane as seen in an autopsy, and diphtherial paralysis.

In the eighteenth century angina maligna was even more prevalent than in the seventeenth, occurring in nearly every country of Europe and in some portions of America. Many localities in Spain and Portugal were invaded by it between the years 1701 and 1786. It prevailed in Paris and in many other towns in France in 1743–50; again in Paris in 1758–9 and in 1762. The first of these epidemics was described by Marteau de Grandvilliers,[1] and by Chomel,[2] who accurately described paralysis of the soft palate, and a case of diphtheritic strabismus. Epidemics occurred in various portions of Italy between 1747 and 1786. One which prevailed in Palermo in 1747–8 was described by Ghisi,[3] who observed laryngeal croup and pharyngeal angina gangrenosa as each occurred separately, and when both were united in the same patient, and noted the phenomena of diphtheritic paralysis. Epidemic outbreaks occurred in Holland between 1745 and 1770. In Great Britain an epidemic of angina maligna, was described in 1713 by Dr. Patrick Blair,[4] under the name of "the croops" as "universal" at Coupar Angus. In 1748 a fatal outbreak in London of scarlatina anginosa, which was complicated with diphtheria, was described by Dr. Fothergill.[5] In 1745–8 a "morbus strangulatorius," which presented the characteristic features of malignant diphtheria, prevailed in Cornwall, and was described by Starr.[6]

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[1] "De Morbis Acutis," lib. ii., sec. iii., cap. 5. Lyon, 1685.

[2] "Estudios sobre o garrotilho ou croup." Lisbon, 1861.

[3] Corradi "Annali delle Epidemie occorse in Italia," iii. 16.

[4] "De Pestilente Faucium Affectu, Neapoli Sæviente Opusculum," auctore Andrea Sgambato. Neapoli, 1620.

[5] "De Epidemico Strangulatorio Affectu," etc. Neapoli, 1620.

[6] "De Morbo Strangulatorio opus." Romæ, 1636.

[7] "De Pedanchone Maligna," etc. Neapoli, 1643.

In 1765 appeared the treatise on croup by Francis Home of Scotland.[7] This work is very important, not only from the completeness of its descriptions and the logical force of its deductions, but also from the fact that it, for the first time, clearly depicts a form of pseudo-membranous disease which was regarded by him and has since been regarded by many others as distinct from diphtheritic angina. According to him croup, or, as he names it, "suffocatio stridula," is a disease which "belongs peculiarly to children." It "has a local situation," being "seldom found at any great distance from the sea-shore," though "very wet and marshy situations sometimes produce it." Its occurrence is also favored by cold and damp weather, and recent attacks of measles, whooping-cough or small-pox predispose to it. It is "a disease of an inflammatory nature," which "appears to be confined chiefly to the trachea, as the patients have no pain in deglutition, and as the fauces are at most but a little redder." "The place first and most particularly affected is the upper part of the trachea, about an inch below the glottis." "The cause of this disease is a preternatural white, tough, thick membranous crust covering often for many inches the inside of the trachea." "This membrane is not attached to the parts below, but is easily separated from them, as there is always matter behind it." There are two forms of the disease, "the inflammatory and less dangerous, and the less inflammatory and highly dangerous." This description is based on twelve cases, of which three were of the former or catarrhal variety, and terminated in recovery, and are given as examples of those which are "common." The other nine were fatal ones, and in all of these autopsies were made, the membrane as above described being found in every one. In only one, which he regarded as complicated with "angina," the throat and tonsils were inflamed and "covered with mucus." There is no mention of an epidemic character nor of contagiousness in the disease described, but it is possibly worthy of note that two of the fatal cases (IV. and V.) were those of a brother and sister, the former having been attacked September 29th, 1760, the latter, October 5th. The treatment he advises consists of blood-letting, blisters, emollient fomentations and cataplasms around the neck, inhalation of the steam of water and vinegar, and gentle sudorifics. Emetics he had not found useful. When the membrane has formed he recommends bronchotomy.

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[1] "Dissertation Historique sur l'espèce de Mal de Gorge Gangréneux qui a régné parmi les Enfants l'année dernière." Paris, 1749.

[2] "Dissert. Hist. sur l'aspect du Mal de Gorge Gangréneux," etc., Paris, 1749.

[3] "Lettere Mediche del Dottore Martino Ghisi." Cremona, 1749.

[4] "Observations in the Practice of Physic," etc. London, 1713.

[5] "An Account of the Sore Throat Attended with Ulcers," by Dr. John Fothergill. London, 1748.

[6] "Philosophical Transactions," 1750, t. xlvi., p. 435.

[7] "An Inquiry into the Nature, Causes and Cure of Croup," by Francis Home, M.D. Edinburgh, 1765.

Diphtheria again prevailed in London and in some other localities in England in 1790–1793.

Epidemics occurred in Germany in 1752, 1755 and 1790. In 1778 Michaelis[1] in Göttingen wrote in confirmation of the descriptions and views of Home. The disease prevailed in the Simmenthal, Switzerland, in 1752, and in many places in Sweden in the years 1755–62. In the latter country Wilcke in 1757 described pseudo-membranous angina.[2]

In New England an epidemic occurred in 1735, which was described by Dr. William Douglas[3] as originating in Kingston township, about fifty miles eastward of Boston, and after prevailing with great fatality in the surrounding country, at length reaching Boston, where it was much milder. The symptoms of this malady, which are fully detailed, are clearly those of scarlatina, but in many instances there was evidently a complicating or secondary diphtheria.

Two years later a similar epidemic is described in a letter from Rev. J. Dickinson,[4] dated "Elizabeth Town, New Jersey, February 20, 1738–9," as having occurred in that place some time previously, a portion of which description is so vivid as to be worthy of quotation. He describes the disease in six forms, the first being evidently scarlatina, or possibly in some cases measles. The second form "frequently begins with a slight indisposition, much resembling an ordinary cold, with a listless habit, a slow and scarce discernible fever, some soreness of the throat and tumefaction of the tonsils; and perhaps a running of the nose, the countenance pale and the eyes dull and heavy. The patient is not confined, nor any danger apprehended for some days, until the fever gradually increases, the whole throat and sometimes the roof of the mouth and nostrils are covered with a *cankerous crust,* which corrodes the contiguous parts and frequently terminates in a mortal gangrene. When the lungs are thus affected the patient is first afflicted with a dry, hollow cough, which is quickly succeeded with an extraordinary hoarseness and total loss of the voice, with the most distressing asthmatic symptoms and difficulty of breathing, under which the poor miserable creature struggles until released by a perfect suffocation or stoppage of breath. This last has been the fatal symptom under which the most have sunk that have died in these parts. All that I have seen to get over this dreadful symptom have by their perpetual cough expectorated incredible quantities of a tough whitish slough from their lungs."

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[1] "De Angina Polyposa Membranacea." Göttingen, 1778.

[2] "Diss. Med. de Angina Infantum." Upsala, 1764.

[3] "The Practical History of a New Epidemical Eruptive Miliary Fever with an Angina Ulcusculosa which prevailed in Boston, New England, in the years 1735 and 1736. Printed and Sold by Thomas Fleet.

[4] "Observations on that Terrible Disease, Vulgarly called the Throat-Distemper, with Advices as to the Method of Cure." In a Letter to a Friend. By J. Dickinson, A.M. Boston: Printed and Sold by S. Kneeland and T. Green in Queenstreet over against the Prison, 1740." Jonathan Dickinson was the first President of Princeton College and the first pastor of the Presbyterian church of Elizabeth, N. J.

Dr. Cadwallader Colden[1] traces the progress of the epidemic from Kingston westward, it appearing "first in those places where the people of New England chiefly resorted for trade, and in the places through which they travelled" until it "spread over all the British colonies in the Continent," "children and young people" being "only subject to it;" but he adds nothing of importance to the two descriptions of the disease just quoted.

In 1771 appeared the classical treatise of Dr. Samuel Bard[2] of New York, who described with clearness and accuracy pharyngeal, laryngeal and cutaneous diphtheria, occurring separately and in the same patients, from clinical observation and post-mortem examination, as pseudo-membranous but not gangrenous affections, and believed that these various forms of disease, with those described by the Italian writers and by Home, Fothergill, Huxham and Douglas, were essentially related and "arise from the same leaven." He also described consecutive paralysis affecting deglutition, speech and locomotion, and emphasized the infectiousness of the disease and the importance of isolating the sick.

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[1] "Extract of Letter from Cadwallader Colden, Esq., to Dr. Fothergill concerning the Throat Distemper," dated Coldenham in New York, 1753. Published in London Observations and Inquiries, vol. i., p. 211.

[2] "An Enquiry into the Nature, Cause and Cure of the Angina Suffocativa or Sore-Throat Distemper as it is commonly called by the Inhabitants of this City and Colony. By Samuel Bard, M.D., and Professor of Medicine in King's College, New York. Printed by S. Inslee and A. Car, at the New Printing-Office in Beaver Street, MDCCLXXI." Reprinted in Transactions of the American Philosophical Society, Philadelphia, 1789.

Although the masterpiece of Bard has in recent times been appreciated at its true value, it does not seem to have commanded the contemporaneous attention which it merited, and the ideas of Home maintained their ascendancy.

Their influence is illustrated in a "letter on the croup" from P. Middleton,[1] M.D., to Mr. Richard Bayley, surgeon, New York, dated New York, November 30, 1780. He says, "When I first came (from Scotland) to this city in 1752, I found complaints of the throat not infrequent, but most of them were usually considered as having a malignant tendency if not actually anginæ gangrenosæ, and in consequence of this general belief antiseptics were the remedies used in preference to all evacuants except perhaps emetics." He proceeds to state his belief that croup is "totally distinct from malignant sore throat," and asserts that though the two affections may be united, he has never seen such an instance.

Similar views appear in a letter on the croup from Professor Richard Bayley[2] to William Hunter, M.D., London, published about 1781. He quotes with approval the post-mortem observations of Bard, but regards angina trachealis as an "inflammatory" affection, and, like Dr. Middleton, has treated it successfully, even in its advanced stages, by the vigorous employment of venesection, blisters, mercurial evacuants and emetics.

Dr. John Archer,[3] in a letter to Benjamin Smith Barton,

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[1] Medical Repository, New York, vol. xiv., p. 347.

[2] Medical Repository, New York, vol. xii., p. 331, and vol. xiv., p. 345.

[3] Medical Repository, New York, vol. ii. p. 27.

M.D., of Philadelphia, dated Hartford County, Maryland, March 17, 1798, likewise considers croup as a "topical disease, confined to the trachea arteria, and the several ramifications thereof."

In France, also, at this period most writers held the same views regarding the distinct nature of croup and angina maligna.

Several members of the imperial family having died of the former disease, a prize was offered by Napoleon I. for the best essay upon it. This prize was divided between Jurine, of Geneva, and Albers, of Bremen. Jurine recognized the fact of the frequent concurrence of croup with angina gangrenosa, and expressed doubt as to the actual existence of gangrene in the majority of cases of the latter disease.

At length appeared the writings of Bretonneau, which may be said to have founded on a firm and broad basis the modern knowledge of diphtheria. Many of the facts which he announced respecting the disease had, as we have seen, been previously observed and stated by others. It was his glorious achievement to establish them by incontrovertible demonstration and to present them in their true relations. The principal writings of Bretonneau[1] consist of five papers or memoirs, the first two of which were read at the Académie Royale de Médecine in 1821; the last was published in 1855. His studies of the disease were principally made in three great epidemics, that of Tours in 1818, de la Ferrière in 1825, and Chenusson in 1826. The most distinctive feature of Bretonneau's work was the great amount of necroscopic research which it comprised, sixty autopsies being referred to in the first epidemic alone. Among the most important points established by his observations were the absence of gangrene in most cases of diphtheria, the nature and the relations of pseudo-membrane, its frequent continuity and its essential unity in the buccal, the naso-pharyngeal and the laryngo-tracheal regions, the specificity of the diphtheritic inflammation in distinction from the catarrhal and from other specific phlegmasiæ, the non-identity of membranous and "spasmodic" croup, and the true relation of sequence and causation between the local and the constitutional phenomena of diphtheria, which he expressed in the phrases, "localized primitive diphtheria" and "the secondary or constitutional affection."[1]

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[1] "Des inflammations spéciales du tissu muqueux et en particulier de la diphthérite, ou inflammation pelliculaire connue sous le nom de croup, d'angine maligne, d'angine gangréneuse, etc., Paris, 1826." "Sur les moyens de prevenir le developpement et les progrès de la diphthérie." Archives Générales de Médecine, 1855.

The teachings of Bretonneau were ably seconded and amplified by various writers, among the earliest of whom were Guersant,[2] Louis,[3] Gendron[4] and Mackenzie,[5] the two latter of whom were among the earliest advocates of the topical use of nitrate of silver.

During the earlier half of the present century the prevalence of diphtheria greatly diminished, except in France where numerous epidemics occurred between 1810 and 1843, and again from 1846 to 1855. In other European countries and on this continent it was either unknown or occurred only sporadically or in occasional and limited epidemics. In 1856, an outbreak having occurred at Boulogne, in France, which was especially fatal among the resident English, the disease was conveyed to England and prevailed there in numerous and fatal epidemics until 1863. At about the same time a new and more general outbreak than had ever before occurred began not only in Europe and America, but also in Asia, Africa, Australia and Polynesia; and that general prevalence of the disease has since continued, though often in a greatly mitigated form, until the present time, so that in most of the cities of the world at the present day diphtheria contributes a considerable annual quota to the list of mortality.

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[1] Fifth Memoir.

[2] Dictionnaire de Médecine, Articles "Angine Couenneuse," t. ii., "Croup," t. vi., and "Stomatite Couenneuse," t. xix.

[3] "Du Croup consideré chez l'adulte," Arch. Gen., t. iv., pp. 1 and 369.

[4] "Observations sur une Angine Couenneuse," Journal Complémentaire du Diction. des Sciences Med., t. xxiii., p. 346.

[5] "On the Symptoms and Cure of Croup," Edin. Med. and Surg. Journ., vol. xxiii., p. 294.

Under these circumstances it is not surprising that the literature of the disease has assumed enormous proportions, and is less and less occupied with accounts of particular epidemics and more and more with questions relating to etiology, pathology, and therapeutics.

As various writers will necessarily be referred to in the chapters on these subjects, but few additional ones need now be enumerated. Deslandes, in 1827,[1] in considering the question of the identity of pseudo-membranous angina and croup, gave a minute and valuable historical review of the subject of epidemic sore throat. His views on the question referred to accord affirmatively with those of Bretonneau. The doctrine that diphtheria is a primarily constitutional affection was advocated by Emangard,[2] who attacked the views of Bretonneau from the point of view of the "physiological" school, maintaining that the disease is of malarial origin and of kindred nature to typhus—a "gastro-enteric angina." Fuchs[3] also, after a historical review of the subject, held that angina maligna was a "typhus" identical with the pulpous form of hospital gangrene.

Both of these questions, namely that of the identity or diversity of membranous croup and diphtheria and that of the primarily local or constitutional nature of diphtheria, have since been discussed by many writers from opposite points of view, representing a diversity of opinion which continues to the present day.

Trousseau,[4] the friend and pupil of Bretonneau, was his worthy continuator, and supplemented his work by adding from 1829 to 1858 observations which were necessary to the complete description of diphtheria, especially in reference to its cutaneous form and its constitutional manifestations, including albuminuria and the various forms of resultant paralysis. Trousseau was, moreover, like Bretonneau, a warm advocate of tracheotomy, and devoted much attention to perfecting its method and details. The statement of Bretonneau that diphtheria is never accompanied by true gangrene, was shown to be subject to many exceptions by Trousseau and also by Becquerel,[1] Rilliet and Barthez,[2] and Simon.[3]

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[1] Journal des Progrès des Sc. Med., t. i., p. 152.

[2] "Examen Critique du Traité de la Diphthérie par M. Bretonneau." Paris, 1829.

[3] "Historische Untersuchungen über Angina Maligna und ihr Verhaltniss zu Scarlach und Croup." Würzburg, 1828.

[4] "Mémoir sur une epidémie d'Angine Couenneuse Scarlatineuse,"

The occurrence of albuminuria in connection with diphtheria was first discovered in 1857 by Dr. W. F. Wade,[4] of Birmingham, and was soon after independently observed by Dr. Germain Sée, of Paris.[5]

Diphtheritic conjunctivitis was first elaborately treated of by Von Graefe[6] in 1857. His publication was closely followed by that of Prichard.[7]

The first important publication on the subject of diphtheritic paralysis was that of Maingault.[8]

The first precise description of the anatomical distinctions between the different forms of inflammation of mucous membranes by Virchow in 1847, and the first announcement of the discovery of a supposed bacterial cause of diphtheria by Lay-

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Arch. Gen., t. xxi., p. 541; " De la Diphthérite Cutanée," ibid., t. xxiii., p. 383; " Leçons Cliniques sur les Angines," Gaz. des Hôp., Nos. 86, 89, 100, 104, 109, 115, 119, etc.

[1] "Relation d'une Epidémie d'Affections Pseudo-membraneuses et Gangréneuses qui a regne à l'Hôpital des Enfants," Gaz. Med., Nos. 43, 44, 45, 46.

[2] "Maladies des Enfants," t. i., pp. 285, 316.

[3] Considérations sur l'Angine Gangréneuse et de son traitement," Bull. de Thérap., t. xxiv., p. 401.

[4] Midland Quarterly Journal of the Medical Sciences, April, 1858.

[5] Union Médicale, 1858, p. 497.

[6] Archiv. f. Ophthal., b. 1, s. 168.

[7] British Med. Journ., 1857, p. 981.

[8] Thése de Paris, 1854.

cock in 1858, and many important subsequent pathological and etiological investigations by others, will be more appropriately referred to elsewhere in this work.

In treatment, hydrochloric acid, alum, and later nitrate of silver, were locally employed by Bretonneau, and in some cases mercury internally. Tonics were advocated by Becquerel[1] in 1843; alkaline treatment by Baron[2] in 1851; chlorate of potassa by A. Smith[3] in 1855; iodine by Lecointe,[4] and bromine by Ozanam[5] in 1856; muriated tincture of iron internally by Heslop in 1858;[6] iron and chlorate of potassa by Kingsford;[7] sulphur by Duché[8] in the same year, and turpentine by Perry[9] in 1859.

A method of intubation of the larynx having been devised and warmly advocated by Bouchut, a report on the subject was presented to the Académie de Médecine by Trousseau in 1858, so unfavorable that the procedure was condemned by the general verdict of professional opinion, was abandoned by its author, and fell into such oblivion that when Dr. Joseph O'Dwyer, of New York, a quarter of a century later, invented and perfected the method of intubation which has rapidly won acceptance among the great therapeutical improvements of the age, he did so in ignorance of the fact that his idea had been anticipated.

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[1] Op. cit.

[2] Gazette Méd., 1851, p. 524.

[3] Dublin Hosp. Gazette, vol. ii., p. 149.

[4] Bulletin de Thérap., t. i., p. 70.

[5] Comptes Rendus de l'Acad. des Sci., t. xlii., p. 102, and Mon. des Hôp., p. 551.

[6] Med. Times and Gazette, vol. xxxvii., p. 552.

[7] Lancet, 1858, p. 484.

[8] Gaz. des Hôp., Nos. 125 and 133.

[9] Med. Times and Gaz., vol. xxxix., p. 245.

CHAPTER II.

ETIOLOGY.

The causes of diphtheria are not fully known. The knowledge which we have respecting them is derived from the observation of the circumstances under which the disease naturally occurs, the results of experiments for its artificial production, and certain facts in its pathology.

Among the circumstances which ordinarily influence the occurrence of diphtheria, one of the most noteworthy is that of *age*. While no period of life is absolutely exempt from its attacks, it is in the great majority of cases a disease of childhood. Among nearly 70,000 fatal cases comprised in the returns of the Registrar General of England, and analyzed by Dr. Thursfield,[1] the numbers per thousand of the different ages were as follows:—

Under 1 year,	90
From 1 to 5 years,	450
" 5 " 10 "	260
" 10 " 15 "	90
" 15 " 25 "	50
" 25 " 45 "	35
45 years and upwards,	25

The following table, compiled from the records of the Board of Health, shows the ages in 14,688 fatal cases of diphtheria which occurred in this city during the ten years, 1873–1882. It will be seen that over eight per cent. of all were under one year, over seventy-three per cent. of all under five years, and over ninety-five per cent. of all, under ten years.

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[1] London Lancet, August 3, 1878.

Under 1 year of age,	1,214
Over " " " and under 5,	9,622
Total under 5,	10,836
Over 5 years and under 10,	3,212
Total under 10,	14,048
Over 10 years and under 15,	311
" 15 " " " 20,	87
" 20 " " " 25,	53
" 25 " " " 30,	37
" 30 " " " 35,	34
" 35 " " " 40,	28
" 40 " " " 45,	25
" 45 " " " 50,	16
" 50 " " " 55,	12
" 55 " " " 60,	12
" 60 " " " 65,	8
" 65 " " " 70,	3
" 70 " " " 75,	6
" 75 " " " 80,	6
" 80 " " " 85,	0
" 85 " " " 90,	2
Total	14,688

In some local outbreaks of diphtheria, however, of exceptional malignancy, the proportion of adults affected has been much greater.

The reason of this comparative defencelessness of children against the invasion of diphtheria is doubtless mainly the softness and delicacy of their mucous membranes, which are consequently especially susceptible to irritating influences, penetrable by morbific poisons, and liable to inflammatory affections in general.

Diphtheria occurs by marked preference in connection with various pre-existing diseases, especially those which produce inflammation, erosion or ulceration of the mucous membranes of the outer air-passages.

For similar reasons the invasion of the skin by diphtheritic inflammation is rendered practicable by the removal of the epidermis by wounds, blisters, etc.

Diphtheria occurs by preference in some persons through individual or family predisposition. Some instances of great mortality in families which have been cited by authors in support of this statement were probably merely illustrations of the action of intense endemic influences, but I have known individuals and families of children to suffer from repeated attacks of the disease in the apparent absence of such influences, in several successive places of residence, and when others living in exactly the same conditions were exempt.

One attack of diphtheria affords a temporary immunity from subsequent ones; but this is usually, at least, of comparatively short duration. Second attacks of diphtheria after an interval of a year or more are not uncommon. The severity of recurrences of the disease does not seem to differ in any way from that of primary attacks.

Diphtheria occurs under the most widely varying conditions of climate, temperature and season, being dependent upon none; but its occurrence is nevertheless favored by cold and dampness.

In support of the former assertion it may be stated that diphtheria prevails in tropical countries, such as Tunis, Algiers, Egypt and the East Indies, as well as in Iceland and Labrador; during periods of drought as well as of humidity; in summer as well as in winter.

The other assertion, *viz.*, that the occurrence of diphtheria is as a general rule favored by cold and by humidity, is proved by the fact that it is more prevalent in those regions and at those seasons of the year in which those conditions are in the ascendant. In reference to its occurrence in different climates, Hirsch says,[1] "Its predominance in the temperate and cold zones compared with its rarity in the equatorial and subtropical regions is great enough to be significant, even if we assume that those differences are only in part real and in part to be accounted for by the defective data from countries of the latter class."

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[1] Op. cit. p. 100.

With reference to seasons of the year he states, "In 124 epidemics of which we have exact data in regard to their duration, all of them being closely circumscribed in place and of no more than a few months' continuance, the outbreaks reached their height as follows:

32 in the spring.
24 " summer.
30 " autumn.
38 " winter."

Of 18,688 fatal cases which occurred in this city in the thirteen years from January 1, 1874, to December 31, 1886, according to the records of the Board of Health, 10,769 occurred in the half years beginning with October, and 7,919 in those beginning with April. The distribution by months is shown in the following table:

Years	Jan.	Feb.	M'ch.	April.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
1874	140	97	111	115	102	99	109	103	108	201	251	229	1,665
1875	232	196	180	189	165	195	167	147	175	206	210	267	2,329
1876	274	242	209	158	186	130	81	79	68	103	102	118	1,750
1877	72	70	84	79	67	50	56	53	85	111	116	108	951
1878	132	94	105	90	81	72	50	47	55	75	101	105	1,007
1879	97	69	58	36	46	46	32	39	30	71	76	71	671
1880	72	77	65	81	76	61	89	97	125	199	234	214	1,390
1881	212	160	180	164	190	209	197	173	173	203	178	210	2,249
1882	218	169	181	154	156	133	95	78	63	88	97	93	1,525
1883	104	87	88	92	92	82	66	73	62	82	81	100	1,009
1884	79	82	73	77	83	92	70	62	55	127	139	151	1,090
1885	108	121	121	115	102	115	101	71	87	87	122	175	1,325
1886	155	149	134	124	142	130	133	104	85	165	288	218	1,727
M'thly Totals.	1,895	1,613	1,589	1,474	1,488	1,414	1,246	1,126	1,171	1,618	1,995	2,059	18,688

Cold and dampness undoubtedly favor the occurrence of diphtheria mainly as predisposing causes, by their tendency to excite catarrhal affections, the relation of which to diphtheria has already been referred to.

A relation of cause and effect between conditions of soil and situation and the occurrence of diphtheria is asserted by some authorities and denied by others. Hirsch[1] presents an accumulation of testimony from observers in different countries to the effect that the development and epidemic diffusion of the disease are absolutely independent of such conditions, the evidence showing that high and low, dry and damp situations and all geological formations have been equally the seat of its prevalence, and that the instances in which it has preferred low, damp, and ill-drained locations are fully offset by others in which it has apparently made the opposite choice.

The full acceptance of these facts is, nevertheless, not inconsistent with the view that local dampness does favor the occurrence of diphtheria.

Dr. N. M. Thursfield, whose careful attention to this subject, and exceptional opportunities for observation in his capacity as Health Officer of a district comprising a large urban and rural population, entitle his views to the most respectful consideration, says:[2]

"While I believe that no very close connection can be traced between the incidence of diphtheria and what are broadly known as geological formations, there is the closest connection between certain conditions of subsoil and situation of the house, and the disease. Whatever promotes dampness of habitation, the result is the same.

"M. Trousseau appears to have formed his opinion that the disease had no connection with local surroundings, from the fact that he had seen it raging equally on low undrained localities and on breezy heights. I have been called upon on several occasions to investigate outbreaks of diphtheria on elevated open localities, and have invariably found the same condition of dampness of habitation, caused by faulty construction of the houses in localities where there was a stagnation of water, either from a flat table-land with an impervious sub-soil, or, more frequently, from the locality being the division of a water-shed, which is always a cause of stagnation of water."

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[1] Op. cit. p. 104.

[2] London Lancet, August 10, 1878.

Diphtheria, as a general rule, prevails with greater fatality in rural regions than in cities. This fact, which has been noted in the history of many epidemics, is illustrated by Dr. Thursfield[1] in tables which show a much larger percentage of deaths from diphtheria to population in ten rural counties than in ten principal cities of England throughout a series of years. Dr. Thursfield remarks, "Whatever conditions seem to favor fungoid growth would seem to favor the incidence and persistence of diphtheria, and the explanation of the comparative freedom of towns from the disease may be the presence of something in their atmosphere inimical to such growth."

May not a partial explanation, however, be found in the fact that the inhabitants of cities are, upon the whole, better sheltered from the inclemencies of the weather and less exposed to "dampness of habitation" than those of the country?

Diphtheria may occur independently of insanitary conditions. Indeed in some epidemics it has seemed to find most of its victims in circumstances where the action of such causes could least be suspected. There is, nevertheless, abundant evidence that its occurrence is favored by them. The instances of its outbreak and prevalence in the country in direct connection with such sources of infection as damp and filthy cellars, stagnant pools reeking with the products of the decomposition of animal and vegetable substances, foul privies, wells contaminated with excrementitious matter, etc., and, in cities, with bad sewerage and defective plumbing and ventilation, and the combined results of poverty, filth and overcrowding of habitations, are too numerous and striking to be rationally regarded as mere coincidences.

As out-door visiting physician to the Demilt Dispensary in the twenty-first ward of this city through a number of years, I have had many opportunities of observing the relation of occurrences of diphtheria to this class of causes, and was long ago impressed with its tendency to occur and recur in certain tenement-houses where some of these conditions were most marked—such especially as foul and ill-drained cellars, neglected and sometimes overflowing cess-pools, and bad plumbing, with untrapped sinks and no air-shafts. The relation of cause to effect in these instances has been demonstrated by the fact that in some of these buildings, which had come to be looked upon by me and by my assistants as diphtheria nests, there has been no recurrence of the disease for quite a number of years since the evils referred to were removed through the efforts of the Board of Health. It is probable, moreover, that it is, in some degree, at least, a result of the removal of these foci of the disease that the mortality from diphtheria in this district, which was in 1875 in proportion to population among the greatest in the city, has for quite a number of years been among the least.

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[1] Loc. cit.

In estimating the validity of the argument which has been urged against this view, from the fact, already referred to, that in many epidemics diphtheria has been observed to prevail among all classes indifferently, or even in some instances especially among the classes whose hygienic surroundings were the best, it may be remarked that insanitary conditions are only one among many causes of diphtheria, and are certainly not essential to its occurrence; that they constitute the most potent factors in its *endemic* prevalence, but that when it is epidemic other causes, more direct and potent and yet to be considered, are often the efficient ones; and again, it is a serious and dangerous error to assume that insanitary conditions are found only in the abodes of the poor. Unfortunately the application of sanitary science to the construction of dwellings has not yet attained such perfection, nor is its assistance so generally and so intelligently invoked even in the abodes of the wealthy, that any absolute line of demarcation can be drawn between them and the dwellings of the poor, either in city or country, in respect to their liability to or exemption from the causes of zymotic disease. In some instances the elaborate and luxurious appliances of modern plumbing have seemed to multiply, rather than to obviate, the insidious dangers from noxious miasms. While, as I have already stated, I have seen many cases of diphtheria, evidently resulting from insanitary conditions in the abodes of the poor, I have also seen equally striking instances of this connection in the homes of the well-to-do and in the mansions of the rich.

Insanitary conditions may favor the occurrence of diphtheria in two ways: by producing diseases which predispose to the reception of the special poison which causes diphtheria, and by the endemic perpetuation and reproduction of that poison, or possibly by its generation *de novo.*

Diphtheria, or a disease which closely resembles it etiologically and pathologically, occurs in various kinds of animals, poultry and birds, and seems to be intercommunicable between them and man.

Facts confirming this statement have been published in great numbers by Nicati,[1] Friedberger,[2] Wood and Formad,[3] Turner,[4] Delthil,[5] Paulinis[6] and many others. The following instance was published by Gerhardt:[7]

"In the village of Messelhausen, near Landa in Baden, a chicken-farm had been started into which 2,600 chickens had been brought from the country near Verona, Italy. A few of these had diphtheria, and within the first six weeks 600 of them died of the disease, and, later on, 800 more. The following summer 1000 chickens were hatched from eggs laid by these hens, and all of these died of diphtheria within the first six weeks. Five cats succumbed to the same disease at this farm, and a parrot also took the disease, but was saved. In November, 1881, an Italian rooster, about to be touched up with carbolic acid, bit one of the attendants in the left hand and foot. The man was taken sick with high fever and both wounds were covered with diphtheritic membranes. The wounds healed very slowly, the disease lasting three weeks. Two-thirds of the farm hands became affected with diphtheria, and at the same time not a case occurred in the neighboring village."

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[1] "Compt. rend." 1879, tom. 88, No. 6.

[2] Zeitschr. f. Thiermedecin und vergl. Pathol., 1879, v. 161.

[3] National Board of Health Bulletin, 1882; Supplement No. 7.

[4] Report to the Local Government Board of London, 1887.

[5] Journ. de Méd., Feb. 19, 1888.

[6] Bull. Méd., Jan. 22, 1888.

[7] Verhandlung d. Cong. f. innere Medicin. Wiesbaden, 1883.

Paulinis relates that on an island in the Greek Archipelago on which diphtheria had been previously unknown, an epidemic among its population resulted from taking thither turkeys affected with the disease. The contagion seemed to be transmitted through the atmosphere. The affection in the turkeys resembled in all its features the human disease. One of them which recovered was affected with paralysis and was unable to walk.

Diphtheria occurs as the result of contagion and infection. This is abundantly demonstrated. Volumes might be filled with the recorded facts which illustrate it, such as the first introduction of the disease into a family or a school or a neighborhood by the arrival of a person suffering from it, and its subsequent dissemination by communication from one to another throughout the community, or its introduction into one country from another in the same manner, and its subsequent epidemic diffusion through that country along lines of travel and from one centre of infection to another. Such instances are far too numerous and precise to admit of explanation merely by endemic or epidemic influences. Nor is their force in the least weakened by the fact that many cases and epidemics have occurred which could not be thus accounted for. Diphtheria is contagious, though all cases of diphtheria are not due to contagion.

Diphtheria is contagious in a less degree than scarlatina or measles or small-pox or whooping-cough; it is less infectious than scarlatina or variola or typhoid fever; nevertheless in many instances it manifests both these qualities in an extreme degree.

Diphtheria is communicated in a variety of ways. The first of these is by direct contact or the deposition of diphtheritic matter on the mucous membrane or upon wounds in the skin.

Examples of this mode of transmission are furnished by numerous well-known instances in which physicians have contracted the disease by sucking out tracheotomy tubes, or by receiving the secretions of the patient in the mouth or nares; also by such instances as that related by M. Sée,[1] in which a woman who wet-nursed a child affected with diphtheria, communicated labial diphtheria to her own child, which she also nursed, and received the same affection from the latter by frequently kissing it.

The demonstration afforded by the instances referred to is not at all weakened by the fact that many other physicians have sucked out tracheotomy tubes and have received diphtheritic secretions in their mouths and nares, or that other mothers have suckled and kissed infants affected with diphtheria, or that M. Peter[2] and others have painted their own fauces with solutions of false membrane without diphtheria resulting. The power of resistance of the healthy mucous membranes, especially in adults, to diphtheritic infection, is, undoubtedly, very great, and the infective power of diphtheritic material from different sources, as will be shown further on, varies very much. Under these circumstances a limited number of positive examples of the communication of diphtheria by direct contact, among many negative ones, is all the proof of its occurrence that could rationally be demanded.

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[1] Bulletin de la Soc. Med. des Hôp., t. iv., p. 378.

[2] Trousseau, Op. cit., vol. i.

Diphtheria may be communicated by inoculation. Indeed this is implied in the fact of its communicability by direct contact, since in that mode of transmission penetration of the epithelium by the infecting matter is evidently an essential condition.

The communicability of diphtheria by inoculation is illustrated in such instances as that related by Dr. Paterson,[1] of the disease being communicated to a wound on a finger which was thrust down the throat of a child who was suffering from it. In other instances inoculation has been effected by the biting of the finger by the child.

I witnessed not long since an instance of auto-inoculation by transplantation. A lady whom I saw in consultation with Dr. C. L. Lang of this city had labial diphtheria. She was also suffering from eczematous spots on her lower limbs which annoyed her by itching and burning. To allay this discomfort she placed upon one of them, which was particularly accessible and troublesome, a bit of blotting-paper moistened with her saliva. In a day or two this patch became diphtheritic and continued so for some days, but none of the neighboring patches was similarly affected.

That the communication of diphtheria by inoculation is attended with difficulty and uncertainty, is shown by the fact that Trousseau, Peter and Duchamp scarified their own fauces with scalpels charged with diphtheritic matter without result. Experiments in the inoculation of animals with diphtheritic matter have been attended with very varying results. These have been negative in many instances, as in the attempts of Bretonneau, Reynal, Harley and others. Trendelenberg,[2] in sixty-eight operations in which he introduced diphtheritic pseudo-membrane into the trachea of rabbits and pigeons, produced tracheal diphtheria in eleven, most of which died of croupal asphyxia. With the membrane obtained from these victims he performed a second series of experiments with similar results. Oertel,[1] in twelve similar experiments upon rabbits, produced tracheal diphtheria in eight, five of which died by asphyxia, and three from toxæmia, the autopsies showing capillary hemorrhages in various organs, and marked renal congestion. With the membrane obtained from these rabbits he produced similar results in a second series of operations, and repeated them in a third. Drs. H. C. Wood and Henry F. Formad [2] performed intra-tracheal inoculation upon rabbits with like results in a small proportion of instances.

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[1] Med. Times and Gazette, 1866.

[2] Arch. für Klin. Chir., t. x., 1869.

Hueter and Tommasi and Oertel introduced diphtheritic matter into the muscles of rabbits. The result [3] was a diphtheritic layer on the edges of the wounds, hemorrhagic inflammation of the muscles and a general disease which proved fatal after one or two days. Nassiloff and Eberth,[4] by inoculating the cornea, produced diphtheritic keratitis which was accompanied with a general affection which proved fatal on the fourth or fifth day. The evidence that the affection induced in these instances was true diphtheria has been regarded as inconclusive by many. Drs. Curtis and Satterthwaite [5] repeated these operations. In those made upon the cornea by them the result was negative. Of thirty-eight rabbits inoculated by them with diphtheritic matter in the muscles or by subcutaneous injection twenty-one died after periods varying from thirty hours to thirty-eight days. In these cases the authors "failed to see anything specifically resembling diphtheria as it occurs in the human subject. The whole story seemed to be one of local irritant poisoning which always tended toward the production of an abscess at the site of the inoculation, with greater or less concomitant hyperæmia, ecchymoses and serous infiltration of neighboring tissues according to the degree of virulence of the inoculated poison."

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[1] Deutsch. Arch. für Klin. Med., 1871.

[2] National Board of Health Bulletin, 1882; Supplement No. 17.

[3] Ziemssen's Cyclopædia, vol. i.

[4] Correspondenzblatt, 1872.

[5] "Report of Investigations into the Pathogeny of Diphtheria," by Edward M. Curtis and Thomas E. Satterthwaite. New York, 1877.

Drs. Wood and Formad,[1] on the other hand, in a small proportion of their subcutaneous and intra-muscular inoculations of rabbits with diphtheritic matter, produced a rapidly fatal local and general affection, which strikingly resembled diphtheria, and which they regarded as probably essentially identical with it.

In the recorded experiments for the communication of diphtheria to the lower animals by inoculation it is to be observed that the operation is attended with great uncertainty, succeeding in only a small proportion of all cases; that it has usually failed when attempted in the mucous membrane of the mouth and fauces, but has much more often succeeded in the trachea.

Diphtheria may be communicated from one person to another through the circumambient air. This is undoubtedly its most usual mode of communication, as has been illustrated in the numerous instances in which the disease has been contracted by persons entering rooms or houses in which were patients suffering from it, or has been brought by those affected with it to persons or families previously exempt from it. The distance to which the disease can be thus conveyed by the atmosphere is ordinarily very small, though in some epidemics it has seemed to be wafted by the winds to considerable distances.

The contagion from patients affected with diphtheria seems to accumulate in their rooms, to adhere to walls and furniture, and often to linger for a considerable time after their recovery, as has been shown by numerous instances in which persons have taken diphtheria in rooms in which cases of the disease had occurred weeks or months before. It seems also to linger about the persons or in the clothing of those who have had the disease for some time after their recovery. Some recorded instances also seem to show that the contagion may be carried in the clothing of those who have been exposed to the infection of the disease, but not affected with it themselves, and communicated by them to others.

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[1] Loc. cit.

The following is one of many such instances: Dr. J. H. Salter[1] states that in a farm-house situated in a high and dry locality, and several hundred yards from any other house, a boy of eleven years was attacked with diphtheria on October 24th, and within the next six days his father, another child and three servants came down with the disease. There was no epidemic in the neighborhood. It was learned on investigation that on October 19th a woman from another village, two miles away, had brought back some needlework from her cottage, which contained at the time two sick children. One child had died rather suddenly from what was called "bronchitis." The other was seen by the health-officer with well-marked diphtheria. There were no other cases for miles around. The infection seems to have been carried by the woman in her clothing or in the needlework. She did not herself have the disease.

The contagion of diphtheria may probably be conveyed by articles of food and drink, such as milk, etc. Observations in some epidemics of diphtheria have seemed to establish some connection between its occurrence and the milk-supply. Some have thought it probable that the disease known as garget in cattle might be a source of diphtheritic infection. The agency of such substances as carriers of diphtheria is, however, not fully demonstrated and is probably not among the very frequent causes of the disease.

That diphtheria occurs epidemically is one of the most notable facts in connection with its etiology. It is evident that at such times the contagion of the disease is more potent than at others, as it is propagated and disseminated by the various modes of communication which have just been enumerated independently of local conditions, and with an intensity and certainty of action which is rarely seen in connection with the endemic and sporadic forms of the disease. This difference in respect to virulence of contagion between epidemic and sporadic or endemic cases is strikingly illustrated in the results of the experiments of Drs. Wood and Formad already referred to. Of thirty-two rabbits inoculated with diphtheritic matter from endemic cases only six died, and none of those from diphtheria; of fifteen, inoculated with matter from the Ludington epidemic, eleven died, and four of these with abundant diphtheritic exudation at the site of inoculation. It is not improbable that many of the discrepancies in the results of exposures to contagion and of inoculation-experiments may be thus accounted for.

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[1] British Medical Journal, Dec 1, 1883.

It is next in order to inquire what is the nature of the contagium of diphtheria. It seems probable that a *materies morbi* which may be communicated by direct contact and by inoculation, which may be suspended in and conveyed by the atmosphere and by gases and liquids, which may be shut up in apartments and adheres for a considerable time to walls and furniture and persons and clothing, and which is reproduced and disseminated in the course of the disease is in the form of solid particles, rather than of a liquid or a gas, or at least is conveyed by such particles. This may also be inferred from the manner in which the disease usually commences upon the mucous membrane of the throat, the nares or the mouth, namely, in points or in small limited non-symmetrical areas rather than with the general diffusion which would characterize the action of an inhaled poisonous gas or vapor either acting from without or from within through the circulation. This probability is also sustained by the results of experiments. Curtis and Satterthwaite[1] state that "Thorough filtration of a proven virulent aqueous infusion of diphtheritic membrane removes the infectious property of the same." And the same results have been reached by many others.

Is this contagium a chemical poison or is it a micro-organism, or, what is practically equivalent to the latter, is it a chemical poison which is the product of such an organism?

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[1] Loc. cit.

Such convincing arguments have of late years been brought forward to prove that the phenomena of contagious and infectious diseases can be fully accounted for by the agency of micro-organisms and in no other way—arguments which are too familiar to need present repetition—that the microbe of diphtheria has long been eagerly sought for by many and its ultimate discovery confidently anticipated by the majority of the profession. No such discovery yet supposed to have been made has met with unchallenged and universal acceptance; yet in the course of the search various facts have been elicited of such interest that a brief review of them is essential to our present inquiry.

Professor Laycock,[1] in 1858, was the first to find a supposed parasitic cause for diphtheria in the oïdium albicans. Other microscopists subsequently observed other organisms in connection with the disease, as the zygodesmus fuscus of Letzerich[2] and the leptothrix buccalis of Jaffé,[3] which were in turn found to be common to other diseases, or even present in conditions of health.

In 1868 the micrococcus,—an organism previously observed by Buhl—was brought forward by Oertel[4] as the specific microbe of diphtheria. The micrococcus is a minute, point-like, dark-contoured, round or oval immovable body, occurring singly, in chains, or in zoöglea (masses).

According to the earlier observations of Oertel the micrococcus was always accompanied in diphtheria by a small form of the bacterium termo (a rod-bacterium). He stated that these organisms were always to be seen in rapidly increasing numbers upon the mucous membrane at points where diphtheritic false membrane was about to develop, but were never present in other forms of inflammation, that they penetrated into the tissues, caused the dissolution of the young cells, filled and obstructed the blood and lymph-vessels, appeared heaped up in the miniferous tubules and the Malpighian corpuscles of the kidneys, and, in short, were found in the most diverse situations and were inseparable from the diphtheritic process. The observations of Oertel were more or less fully corroborated by those of Von Recklinghausen, Nassiloff, Waldeyer, Klebs, Eberth, Heiberg, Trendelenberg and Letzerich.

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[1] Med. Times and Gazette, vol. xxxviii., p. 548.

[2] Virchow's Arch. B. xlv. et seq.

[3] Schmidt's Jahrbuch, 1862.

[4] Studien über Diph. Aertzl. Int., 1868. No. 34.

These views were controverted by Beale,[1] Senator,[2] Billroth,[3] Curtis and Satterthwaite[4] and others, who denied the specific character and the pathogenic function of these parasites in diphtheria.

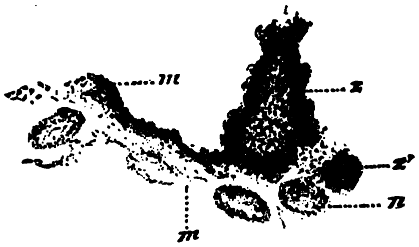

FIG. 1.—Diphtheritic False Membrane Containing Micrococci. *z*, Zoöglea formed by small micrococci; *z'*, Zoöglea formed by larger micrococci; *m*, Isolated microbes. × 500. (Cornil and Babes.)

The observations of Wood and Formad, already referred to, were in some respects in accordance with those of Oertel, though their conclusions were somewhat different. In freshly removed false membrane micrococci only were found by them. Other forms of bacteria were found in membrane which had been removed some hours previously or which was removed post-mortem.

In examinations of the blood of human beings during life, micrococci were found in one of seven cases of sporadic diphtheria, and in seven of fourteen of epidemic diphtheria. The seven of the latter class in which they were not found were mild or in the stage of convalescence. Micrococci were, however, also found in the blood during life of one case of unknown disease in hospital which resulted fatally, and in two of scarlatina anginosa with exudation.

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[1] Disease Germs. London, 1872.

[2] Archiv. für pathol. Anat. und Physiol., t. lvi., 1872.

[3] Untersuchungen über Vegetations-formen der Cocco-bacteria Septica, etc. Berlin, 1874.

[4] Op. cit.

"Both septic animal matter and non-organic irritants placed in the trachea cause pseudo-membranous tracheitis, which we have failed to distinguish from diphtheritic tracheitis, the membrane in both cases containing micrococci. The occurrence of a false membrane in the trachea is the result not of the specific character but of the intensity of the inflammation.

"The micrococci of diphtheria do not differ, so far as observed, from the micrococci of furred tongue, etc., except in their tendency to grow in culture fluids.

"The micrococci of furred tongue or ordinary sore throat have a less tendency to grow under culture than have the micrococci of endemic non-malignant diphtheria; and the latter much less than the micrococci of malignant diphtheria.

"The rapidity of the growth of the micrococci is in direct proportion to the malignancy of the case yielding them and its contagiousness.

"On exposure to the air diphtheritic membrane of the most virulent type loses its contagious power, and the micrococci, *pari passu*, lose their power of growing in culture-fluids.

"Under successive generations of artificial culture the diphtheria micrococci lose their growth activity and also their power of infecting the rabbit.

"It has not been experimentally directly proven, but is a necessary inference from the two facts just stated, that under certain favoring circumstances the sluggish micrococcus puts on growth activity and in all probability poisonous properties.

"Every grade of case may be found in man, from a simple sore throat through simple membranous pharyngitis and tracheitis up to malignant diphtheria.

"Any inflammation of the trachea of sufficient intensity may cause the formation of a pseudo-membrane.

"A case may begin as one of sthenic 'pseudo-membranous croup,' and end as one of adynamic diphtheria with blood-poisoning, and in cases of this character not infrequently no exposure to contagion is discoverable, and there is clinically every reason to believe that the 'blood-poison' has been developed within the body of the patient. The theory of the disease which we would deduce from these facts is that the micrococcus which directly or indirectly causes the diphtheria is not a specific organism different from that common to healthy and inflamed throats, but is an active state of that organism; that certain circumstances outside of the human body are capable of throwing this micrococcus into this condition of active growth and engendering an epidemic of diphtheria. When diphtheria is thus epidemic the micrococci light upon a throat, and, if the throat have little resisting power, as in the child, inflame it, or increase a catarrh already existing into a violent inflammation, and also rapidly enter the blood and cause systemic poisoning. On the other hand, a catarrh in a weakly subject may in the beginning be simply an inflammation from cold, but the ordinary micrococci in the mouth and throat, favored by the special conditions, may gradually change from the dormant to the active state, and by and by act upon the throat and at last force their way into the system, and a self-generated diphtheria be formed out of a cold."

This theory is in essential accordance with that stated by Rindfleisch:[1] "The apparently sudden outbreak of devastating plagues, like cholera, syphilis or diphtheria, is best explained by supposing that a fungus growing as an epiphyte has suddenly gained the power of growing as an endophyte, thus creating an apparently new infection."

Other forms of bacteria have been found by various investigators in apparent pathogenic relation to diphtheria. Among these is the "tilletia diphtheritica," a later discovery of Letzerich[1] than the zygodesmus fuscus. Another is the "microsporon diphtheriticum," described by Klebs[2] as consisting of small micrococci compacted in round balls, surrounded with a thin layer of gelatinous matter. These subsequently develop into minute motile bacilli, and finally into tufts of mycelium.

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[1] "Elements of Pathology."

Klebs stated at the German Medical Congress in 1883, that he had found this form of bacteria in connection with a grave form of diphtheria at Prague, which was characterized by prominent nervous symptoms and hemorrhagic formations in the brain and spinal cord on post-mortem examination. As he had found these organisms transmittible to the cornea, he had regarded them as the specific fungi of diphtheria.

Later, however, at Zurich he had seen cases of diphtheria of an entirely different character. The false membrane of the throat had a great tendency to extend into the larynx and trachea, followed by interstitial inflammatory processes in internal organs. The micro-organisms in these cases were of an entirely different character from those found in former ones. Instead of being globular they were exclusively bacillar formations. Hence he had distinguished two forms of diphtheria—the diphtheria microsporon and diphtheria bacillaris.

M. Talamon, in January, 1881, gave to the Anatomical Society of Paris a minute description of still a different bacterium which he had discovered in connection with diphtheria, and which appears under the form of mycelia and characteristic spores. Talamon had produced diphtheria (or an affection having all its essential features) in rabbits, guinea-pigs, cocks and pigeons by inoculating them with this fungus, and in frogs by simply feeding them with it.

Emmerich[3] arrived at yet different results. The organism which he found to occur distinctively in the diphtheritic lesions of both man and pigeons was neither a coccus nor a bacillus, but a short thick bacterium. Inoculated from cultures into pigeons, rabbits and mice, these bacteria produced characteristic local diphtheritic lesions and a rapidly fatal general disease.

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[1] Loc. cit. [2] Archiv. f. exper. Pathol. und Therap., vol. iv., p. 191.

[3] Deutsch. Med. Wochenschr. 1884, No. 38.

The most important bacteriological investigations which have yet been made in connection with diphtheria are those of Dr. Friedrich Loeffler.[1] Attributing the unsatisfactory results of previous attempts to discover the specific microbe of diphtheria to the inherent difficulties attending them, from the great number of different fungi present in the disease, and also to the insufficient methods which had been employed, since only impure material had been used in cultures and inoculations without separation of the different organisms, he was therefore induced to apply the more accurate methods of Koch to the investigation. He first made histological examinations, with an improved method of staining, of the affected mucous membranes and internal organs of twenty-seven patients who had died of diphtheria, including five cases of scarlatinal diphtheria. In these examinations he found two forms of bacteria especially numerous, *viz.*, micrococci in chains (streptococci) and a form of bacillus. The micrococci were not present in all cases. They were probably the same which had previously been so generally observed in diphtheria.

They were found not only on and in the affected mucous membranes in some cases, but also in the lymphatics, whence they penetrated to every part of the body, causing necrosis of the tissues. Micrococci morphologically identical with these are, however, also found in various other diseases which are accompanied with lesions of the mucous membranes, such as variola, typhoid and puerperal fever, etc., in which diseases their presence is regarded as entirely accidental.

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[1] Mittheilungen aus dem k. Gesundheitsante, Berlin, vol. ii., 1884. Abstracted by Dr. J. W. Hime in "Microparasites in Disease," New Sydenham Soc., 1886, and by Dr. M. Putnam-Jacobi, in the Quarterly Bulletin of the Clinical Society of the New York Post-Graduate Medical School and Hospital, August, 1885.

The bacilli were probably the same which had been first described by Klebs. They are non-motile, either straight or curved, about the length of the bacillus of tubercle, but twice as thick. They were found exclusively in those typical cases of diphtheria which were characterized by thick false membrane in the fauces, larynx and trachea. In this false membrane they were very numerous, and they were found in deeper layers of it than were the micrococci and other accidental bacteria, which only occurred superficially. The bacilli were not found in the internal organs, the blood-vessels or the lymphatics, and if they are really the cause of diphtheria, they are so not by themselves penetrating the system, but by producing a poison which first acts locally, producing tissue necrosis, vascular paralysis and dilatation, and exudation of fibrogenous lymph, and then entering the circulation causes the constitutional disease.

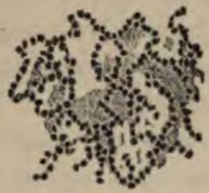

FIG. 2.—The Streptococci found by Loeffler in Diphtheria. × 1250.

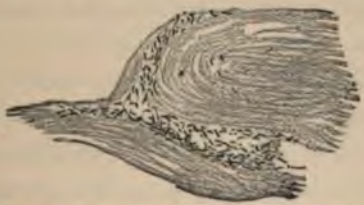

FIG. 3.—Bacilli on the Surface of False Membrane of Vulvar Diphtheria, and in a Crevice between the Filaments of Fibrin which compose it. × 400. (Cornil and Babes.)

The bacilli were not found in all typical cases. It was, however, possible that they might have been present, but have died and been eliminated before the patient's death. The results of the histological investigations were upon the whole inconclusive.

The bacteria described were next cultivated by the usual processes for isolation from the fourth to the twenty-fifth generation.

The products of these cultures were then inoculated upon mice, guinea-pigs, rabbits, monkeys and birds.

Inoculations with the streptococci in no instance produced a disease even resembling diphtheria. For this and other reasons Loeffler concluded that they cannot be regarded as the specific cause of the disease, though it is probable that they may under some circumstances produce a disease resembling diphtheria.

Cultivations of the bacilli introduced beneath the skin of guinea-pigs and small birds killed them, producing whitish or hemorrhagic exudations at the point of inoculation, and extensive subcutaneous œdema, the internal organs being unaffected. Inoculated in the trachea of rabbits, fowls and pigeons, or the vagina of guinea-pigs, the poison produced a false membrane. There was also the characteristic alteration of the vascular walls which shows itself by bloody œdema, hemorrhage into the tissue of the lymphatic glands and effusion into the pleural cavity. The bacilli have, therefore, the same effect as the diphtheritic virus.

Their specific character is seemingly opposed by the following facts: They were absent in a number of undoubted cases of diphtheria; they were not present in typical quantity and arrangement in the artificially produced pseudo-membranes; they had no effect when applied to the uninjured surface of mucous membranes in some animals otherwise susceptible to their action; animals which survived showed no paralysis; identical bacilli were found in the saliva of healthy children. Proof that these bacilli are the cause of diphtheria is therefore incomplete, though the possibility of their being so is not excluded.

The investigations of Babes[1] in twenty-four cases of diphtheria confirmed in a general sense the observations of Loeffler. In every case there were streptococci and the bacilli of Loeffler. In the cultures made from false membranes the streptococci were more numerous, but the bacilli invaded and overwhelmed them, remaining finally the sole masters of the field.

The bacilli were found in the depth of the tonsils in dense masses, and sometimes in the retro-pharyngeal ganglia. In the bronchial ganglia streptococci only were found. These bacteria were in some cases accompanied by other pathogenic microbes—the staphylococcus aureus and an encapsulated microbe resembling that of pneumonia.

In cutaneous diphtheria bacilli were observed not only in the false membrane, but also on the free surface of the papillæ, and in smaller numbers in the connective tissue and the dilated vessels of the inflamed papillæ, and more rarely in the tissue of the derma.

In reference to the organisms of human diphtheria, Cornil and Babes say: "We think that the bacilli of Klebs and Loeffler may be regarded as the most important agents in the production of the false membrane of true diphtheria, but it must be admitted that physiological researches in the case of that disease have not yet given their final response."

Dr. A. D'Espine,[2] President of the Medical Society of Geneva, has found the bacillus of Loeffler in every one of fourteen cases of diphtheria and croup, and absent in all of twenty-four cases of simple anginas studied by him. In a case of croup a pure culture was obtained which preserved its pathogenic powers through twenty-five generations, as was proved by inoculation experiments. Dr. D'Espine believes that this is the pathogenic organism of diphtheria and croup, that it produces a leucomaine which, when absorbed, gives rise to the systemic poisoning, and that its presence or absence may be a reliable diagnostic criterion.

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[1] "Les Bactéries et leur rôle dans l'anatomie et l'histologie pathologiques des maladies infectieuses," par A. V. Cornil et V. Babes. Paris, 1886, p. 458.

[2] Revue Medicale de la Suisse Romande, No. 1, January, 1888, p. 49.

On the other hand, Von Hoffmann-Wellenhoff[1] has found the bacillus of diphtheria of Loeffler in seven cases of pharyngeal diphtheria, in three cases of measles, in six out of nineteen cases of pharyngitis complicating scarlatina, and in four out of eleven cases which had no perceptible abnormalities. Tests in regard to the virulence of cultures of these bacteria showed that a number of those which were obtained from diphtheritic as well as non-diphtheritic cases caused in animals the symptoms described by Loeffler, while other cultures morphologically identical with them were perfectly harmless in the experiments made.

Oertel in his late important work, Die Pathogenese der Epidemischen Diphtherie, Leipzig, 1887, page 141, *et seq.*, referring to his former statement (previously quoted) that he had always found the micrococcus accompanied in diphtheria by a rod-bacterium, states that this rod-bacterium and the bacillus of Klebs and Loeffler very nearly coincide in their measurements, and also in the knobbed appearance of one or both of their extremities, and are in all probability identical.

A new series of observations by Oertel on the micro-organisms present in diphtheritic membrane, may be roughly stated as in general correspondence with those of Loeffler.

In a recent series of post-mortem examinations Oertel has failed to find micrococci present in the kidneys in any case. This difference from his earlier observations he explains by the fact that the more recent cases have been of a less markedly septic type than the former ones.

While these facts obviously suggest the hypothesis that diphtheria is the result of a mixed infection by specific bacilli and septic micrococci, Oertel does not consider that this conclusion is as yet fully established.

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[1] Archives of Pædiatrics, January, 1889, from Jahrb. f. Kinderh., xxviii., 2.

Oertel also states that no bacteria can be found in diphtheria in the interior of the diseased cells in any situation, nor in the necrobiotic foci at any stage, nor in the parenchyma of the internal organs, nor on their surface in such situations as make it probable that they are the immediate cause of the disease. Hence it is to be inferred that their morbific action must be due to the chemical poisons or ptomaïnes which they cause to be produced in the substances in which they live. He believes that this poison or virus first passes into and through the epithelium, induces alterations in the tissue-fluids, excites irritation and inflammation, and thus inaugurates the train of morbid and necrobiotic processes which is elsewhere described. In the course of these processes the poison is reproduced both by the multiplication of bacteria

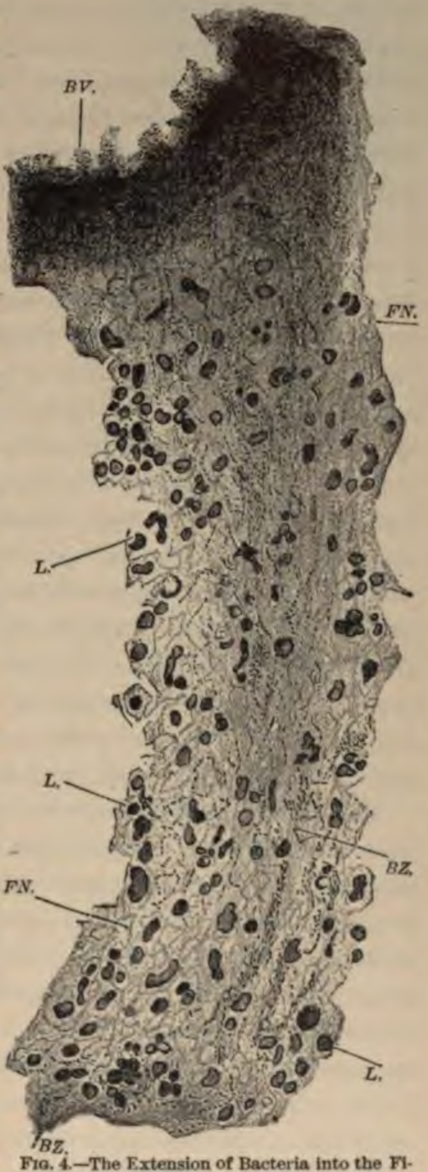

FIG. 4.—The Extension of Bacteria into the Fibrinous Exudation. (Oertel.) *B.V.*, bacterial vegetations; *F.N.*, fibrinous network; *L*, leucocytes, their degeneration, division and disintegration being indicated to a slight extent only; *B.Z.*, chains of rod-shaped bacteria with knobbed extremities.

and by fermentation-changes in the decomposing substances, and becomes more and more widely diffused.

Diphtheria, as a general rule which is subject to relatively very few exceptions, occurs only on those surfaces of the body which are exposed to the access of the air. This suggests that among the conditions which are usually necessary to produce it is the presence of free oxygen. Bacteria, according as the presence of free oxygen is necessary or hurtful to them, are classed as aërobious or anaërobious. From the circumstance just referred to it has been inferred that the bacterium of diphtheria is aërobious. Dr. B. K. Rachford,[1] in taking this view, suggests that the occasional, but rare, occurrence of diphtheria in the stomach and intestines, where free oxygen is not present, may take place under exceptional conditions in which oxygen is supplied in some unstable combination in which it may be utilized for the sustenance of the bacteria of the disease, and that that condition may be one of congestion and erosion of the gastric or intestinal mucous membrane, in which the oxygen is thus supplied by the oxyhæmoglobin of the blood. In proof that this explanation is not far-fetched he cites the fact that strictly aërobic germs, such as anthrax, live and multiply in the body, deriving their oxygen from this source.

The search for the specific bacterium of diphtheria has been stimulated by the general belief that diphtheria is a specific disease like scarlatina or small-pox, which, according to prevalent theories, must have a single parasitical cause. The hypothesis that it may, on the other hand, include several generically related and resembling septic processes with specific differences and dependent on the action not of one but of various bacteria, has been entertained by some and is perhaps, at the present imperfect stage of our knowledge, worthy of a moment's consideration. It is not inconceivable that croupous and diphtheritic inflammation may be capable of being excited by the action of more than one kind of bacterium, as it is known that morbid processes closely resembling them may be by various chemical and mechanical agencies.

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[1] Medical News, Feb. 2, 1889.

This supposition is favored by the remarkable differences which have been observed in the form and course of these processes. The differences in the clinical features and the pathological lesions of constitutional diphtheria are even more striking, and although in the majority of cases they conform to certain general types, yet the deviations from those types are in some instances so wide that they would seem to be more readily explicable by the hypothesis of different infections, or "mixed" infections, than by any other. That mixed infections or intoxications should occur through a favorable habitat being afforded to some pathogenic organisms by tissue changes previously caused by others, or the conversion thereby of previously innocuous to pathogenic ones is in accordance with many known facts.

It can hardly be doubted that the important questions thus suggested respecting the etiology of the various forms and complications of diphtheria, will ere long be finally answered by the multiplication of precise investigations.

The following conclusions from facts and considerations which have now been presented may be regarded as probable:

1. Diphtheria is caused by a parasite which has the following characteristics: Its growth and multiplication outside of the body are favored by dampness and insanitary conditions, and it is reproduced in the disease; its presence on mucous membranes is sometimes innocuous; its vital activity is greatly increased under the conditions which prevail during an epidemic; its pathogenic action is greatly favored by pre-existing morbid conditions of the body, and especially those involving lesions of the epithelium; it is transmitted from one person to another by the various processes which are most usually included under the terms contagion and infection.

2. This parasite causes diphtheria by being implanted on a mucous membrane or a wounded surface of the body or in its

more superficial tissues, and there producing a chemical poison, or ptomaïne.

3. This poison, or ptomaïne, by its direct action on the tissues and vessels causes the local diphtheritic process, in the course of which it is reproduced and more and more widely diffused, and by its absorption from this source into the general circulation causes the constitutional disease.

4. This morbid process is often accompanied or followed by the invasion of the body by other pathogenic bacteria, to which various complications are due.

5. No bacterium thus far discovered in connection with diphtheria can furnish by its presence or its absence a reliable criterion for diagnosis.

Incubation.—The period of incubation in diphtheria—that is, the time from the actual reception of the contagium into the system to the appearance of the disease—is for obvious reasons in the great majority of cases impossible to ascertain. The only cases in which it can be accurately estimated are those in which the disease is known to result from a single exposure of short duration, and even in these cases there is an element of uncertainty, since there is reason to believe that the germ of the disease may be carried about the person innocuously—perhaps even on the buccal mucous membrane—for some time before it begins to exert a morbific influence.

There are, however, abundant data for estimating the minimum period of incubation in instances in which the disease has been brought to the members of a family or a school, or the inmates of a hospital, by persons affected with it. My own observation in many such instances corroborates that of most authors that the minimum period of incubation is usually about two days. Dr. Morell Mackenzie[1] relates an instance in which a child had the disease with abundance of false membrane the next morning subsequent to the afternoon of her first exposure, and another, equally definite, in which the interval between exposure and the development of the disease was fifteen days. A child in a family which had a few weeks before removed from a village in Pennsylvania where there had been no diphtheria to a neighborhood in this city where diphtheria was endemic, took the disease. During her illness her father, who had remained behind, joined his family and at once devoted himself to the care of the child. The second morning (less than two days) after his arrival he came to me complaining of sore throat, and proved to be suffering from diphtheria. The usual period of incubation in diphtheria, in the sense in which the term is defined above, is probably from two to five or six days, though the interval between exposure and the resultant disease may be several weeks.

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[1] Op. cit. p. 29.

In 1876 I saw, with Dr. J. E. Janvrin, of this city, a case of diphtheria at Dobbs' Ferry, of which the history was as follows: Mrs. H., with her son, aged seven, and his nurse, went on September 1st to a hotel at Long Branch. On September 10th Mrs. H. was there attacked with diphtheria. There had previously been other cases in the hotel. The child and nurse were at once sent to their home at Dobbs' Ferry, and Mrs. H. came to a hotel in this city, where she was attended by Dr. Janvrin from September 11th to 19th through a severe attack of pharyngeal diphtheria. She returned to her home on October 1st. On October 24th her son was attacked with a most malignant form of the disease, which terminated fatally. The probabilities in this case were either that the child had carried about himself the germs of the disease for forty-four days or that he had received them from his mother within the twenty-three days before his attack and at least twelve days after her recovery. There had been no previous cases of the disease at that time at Dobbs' Ferry.

[Some recent important contributions to the etiology of diphtheria are appended at page 259.]

CHAPTER III.

PATHOLOGY.

DIPHTHERITIC false membrane may be generally described as a somewhat tough, firm, compact, elastic substance. Its color is a yellowish or grayish white. In thickness it varies from that of a mere pellicle to two or three millimetres, and in extent from a minute patch to a coating of the whole surface of the mouth and throat or a lining of the air-passages. In texture it is usually irregularly fibrillated, but is sometimes amorphous or granular or lamellated, and these conditions are often intermingled. It is tasteless and odorless, is insoluble in water, is dissolved by caustic alkalies, swells up and becomes transparent under the addition of acetic acid, and in its physical and chemical properties closely resembles fibrin.

Under the microscope false membrane is seen to consist of a network of fibrinous threads of varying thickness and closeness, in the meshes or interstices of which are cells, namely leucocytes, red globules or epithelial cells, which have usually undergone a peculiar necrotic transformation. The relative proportions of these elements vary greatly in different cases.

Diphtheritic false-membrane was regarded by the older writers as a gangrenous eschar, by Samuel Bard as altered and inspissated mucus, by Bretonneau and his successors as a coagulated fibrinous exudation analogous to that which occurs on the surface of serous membranes. It will be seen that there was an element of truth in all of these views.

According to E. Wagner[1] false membrane is the result of a peculiar necrobiotic metamorphosis in the epithelial cells, which become enlarged, porous and irregular in shape, sending out peripheral projections which unite with those of adjoining cells, forming a homogeneous network in which nuclei can no longer be detected, and an accompanying infiltration of the corion, and, in some cases, the subjacent tissues, with new cells and nuclei and sometimes extravasated blood.

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[1] Archiv. f. Heilkunde, 1866, Bd. vii., p. 481.

Buhl[1] observed also an infiltration of the tissue of the mucosa, even in situations where it was not covered by false membrane, with cellular or nucleolar bodies. This infiltration he found widely diffused through various organs and regarded as characteristic of diphtheria.

Boldyrew[2] and Steudener[3] opposed the views of Wagner as not confirmed by their observation, and assigned a leading place in the formation of diphtheritic membrane to vascular exudation.

Both of the processes just referred to, namely, fibrinous exudation and the necrotic metamorphosis of cells and tissues, are included in more recent views of the formation of diphtheritic membrane.

The precise circumstances which in all cases favor or prevent the coagulation of inflammatory exudations upon the surface of mucous membranes are not fully known. Weigert[4] has shown that in order that it may take place the epithelium must be wholly or partially destroyed.

The coagulation of fibrin is not a mere solidification of a substance which previously existed as such in solution in the effused fluids, but is a new formation from the fibrin-generators which they contain. According to Alexander Schmidt the plasma of the blood contains fibrinogen, and the white corpuscles and probably other cells furnish fibrinoplastin and a ferment. When the white corpuscles die and are dissolved in the plasma the result is the production of fibrin.

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[1] Zeitschr. f. Biol., Bd. iii., S. 349, 1867.

[2] Archiv. f. Anat. u. Phys., 1872, p. 75.

[3] Virch. Archiv., 1872, liv., p. 500.

[4] Virch. Archiv., Bd. lxxix.

The peculiar metamorphosis of cells and tissues which occurs in the formation of pseudo-membrane was named by Cohnheim coagulative necrosis, and its nature was made known to us chiefly by Weigert. It is a coagulation which occurs not only in effused vital fluids, but in the substance of cells and tissues. That it shall take place it is necessary that the cells or tissue elements shall die or be in the process of necrotic degeneration, and that then effused lymph shall flow through them. Fibrin is formed within the tissue by the union of its two components just referred to. The death of the cells or tissues may be the result of injury from physical or chemical or thermal agencies or from arrested nutrition; the effusion of lymph is due to the vascular changes which accompany inflammation.

Rindfleisch[1] says:

"Coagulation necrosis is to be distinguished from the simple death of a part by the presence of a coagulated albuminous liquid which accompanies the transition from life to death in the cells and tissues. This liquid bears such a strong resemblance to coagulated fibrin that one is tempted to consider them the same, except that the macroscopical and microscopical examination proves that the coagulation is chiefly present in the interior of the cells and in other constituents of the tissues. The microscope shows a peculiar homogeneous tendency of the cell-protoplasm, accompanied by a total disappearance of the nucleus. Thus the cells lose their sharp outline and become flaky masses, inclined to adhere to each other and fall into large irregular formations of membranous consistency. The frequent wax-like appearance of these coagulations is a peculiar feature, indicating their thorough impregnation with a strong refractive albuminous body."

Virchow divided the process by which false membrane is produced, and the resulting false membranes themselves, into two principal classes, the croupal and the diphtheritic. Croupal false membrane may be roughly stated to be that which lies superficially and loosely upon the mucous membrane affected, and is mainly a fibrinous exudation; the diphtheritic that which penetrates it more or less deeply, and is in reality an eschar in it or even beneath it. This classification is now generally admitted to be based on differences in degree and in anatomical relations rather than in essential pathological nature.

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[1] "Elements of Pathology."

Ziegler describes the various processes by which false membrane is formed and their products, according to views now prevailing, with such clearness that I shall quote from his statements:

"*Croupous Inflammation.*[1]—When a mucous membrane is so injured that its epithelium is here and there partially destroyed, and at the same time its blood-vessels are so damaged that an abundant exudation is poured out on the surface, coagulation of the latter may take place. In this way a pale yellowish membrane is formed on the surface, consisting of fibrinous filaments and granules beset with pus-corpuscles, or of shining homogeneous blocks representing cells which have undergone coagulative necrosis. This false membrane is connected with the underlying structures by fibrinous threads, but is usually loosely adherent and can be readily stripped off, disclosing the red hyperæmic mucous membrane beneath.

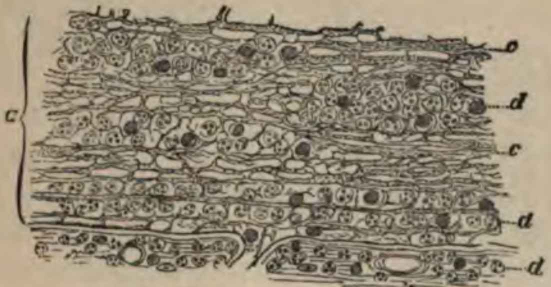

FIG. 5.—Croupous Membrane from the Trachea. (× 250.) *a*, section through the false membrane; *b*, upper layer of the mucous membrane, infiltrated with pus-corpuscles (*d*); *c*, filaments and granules of fibrin; *d*, pus-corpuscles.

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[1] "Text Book on Pathological Anatomy and Pathogenesis," Section 423.

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The epithelial cells are always more or less injured, being either necrotic or in process of degeneration and desquammation. The fibrous structure of the inflamed mucous membrane always contains liquid and cellular exudations.

" *Diphtheritic Inflammation.*—When a mucous membrane is injured in such a way that its epithelium dies without desquamation, while its blood-vessels are damaged and pour out an abundant exudation, it sometimes happens that the dead epithelial cells become saturated with the exuded liquid and then pass into a peculiar condition of rigidity akin to coagulation. The seat of this change appears to the naked eye as a dull grayish raised patch surrounded by red and swollen mucous membrane. The exudation is rich in albumen and the transformed cells take on the appearance of a kind of coarse meshwork almost or altogether devoid of nuclei. The sub-epithelial areolar tissue is beset with filaments of fibrin and leucocytes. Hæmorrhages are not uncommon. Inflammations of this kind, in which the tissue itself coagulates into a solid mass, are called diphtheritic. When the necrosis and coagulation extend

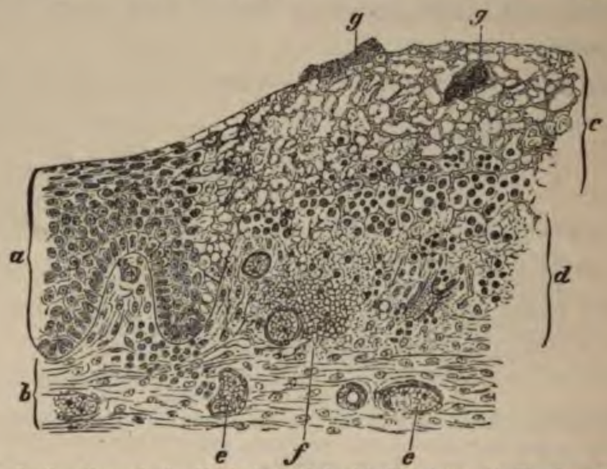

FIG. 6.—Section through the Uvula in Diphtheritis Faucium. (Aniline-brown staining; × 75.) *a*, normal epithelium; *b*, normal areolar tissue; *c*, necrosed epithelium transformed into a coarse mesh-work; *d*, areolar tissue infiltrated with fibrin and leucocytes; *e*, blood-vessels; *f*. hæmorrhage; *g*, heaps of micrococci.

only to the epithelium we may speak of the process as *superficial diphtheritis.* It is by no means necessary" either in croupous or in diphtheritic inflammation, "that the whole of the epithelium should perish at the outset; some part of it at least may perish secondarily in consequence of the inflammation."

The anatomical and histological distinction between the croupous and the most superficial form of diphtheritic false membrane is, therefore, that the former consists mainly of coagulated fibrin and lies superficially over the epithelial cells (sometimes among or beneath them) being connected to the mucous membrane only by filamentous attachments which are easily broken; while the latter, even when superficial and thin, consists mainly of transformed epithelium which remains in close apposition to the inflamed living tissues beneath it, so that if it be torn from them or destroyed by chemical agents a raw and bleeding surface is exposed.

"*Deep or parenchymatous diphtheria* is characterized by the coagulation, not merely of the epithelium but also of the underlying connective tissue. The epithelium in some cases is lost altogether, and then the diphtheritic patch consists of dead connective tissue only. The patch is turbid and granular in texture, or it may be homogeneous or composed of amorphous hyaline blocks. The nuclei are always more or less completely lost. The small vessels which permeate the patch show signs of a homogeneous transformation of their walls. The dead tissue is separated from the living by a zone of cellular infiltration. Fibrinous filaments are seen here and there through the mass. The lymphatics in the neighborhood contain coagula and leucocytes." (See Fig. 7.)

Oertel[1] in his latest work presents with great minuteness and detail the results of his researches into the histological changes which occur in diphtheria. These consist primarily and essentially in a characteristic degenerative metamorphosis in the cells and their nuclei. This takes place especially in the cells "which are derived from the white blood corpuscles, and are known under the collective name of leucocytes." The nucleus shows signs of retrogressive metamorphosis. The nuclear membrane breaks up; the nuclear and the cellular substance run into one mass, and the different forms of chromatin undergo a similar change. The longer this process has continued the fewer are the colorable fragments of nucleus, vesicles, granules, etc. The nuclei or granules exhibit peculiar forms, as if ligatured and partially divided in two; free nuclear and granular vesicles are seen, and others which are connected by minute threads. The protoplasm and the nuclei are transformed into a homogeneous fluid and finally coagulating substance.

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[1] "Die Pathogenese der Epidemischen Diphtherie." Leipzig, 1887.

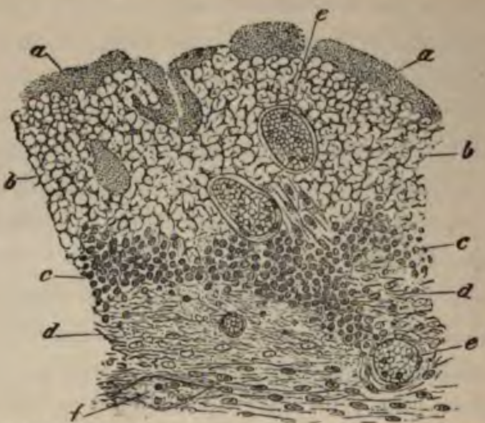

FIG. 7.—Section of the Uvula in a Case of Diphtheritis Faucium. (The epithelium has been shed; aniline-brown staining; × 100) *a*, micrococci; *b*, submucous tissue changed into amorphous blocks; *c*, extravasated leucocytes; *d*, fibrinous exudation; *e*, blood-vessels; *f*, lymphatic vessel containing cells and fibrin.

EXPLANATION OF FIGURE 8.—Section of a Diphtheritic Pharyngeal Mucous Membrane. False membrane invaded by typical rod-shaped bacteria. Cells in different stages of decomposition and division. Necrosis of these cells and of the upper layers of the mucous membrane. Advancement of normal cells from the deeper layers. *a*, necrotic zone; *b*, diseased zone; *c*, apparently normal tissue; *F.N.*, fibrinous network; *B.V.*, bacterial vegetations; *K.B.*, vesicular nuclei with parietal arrangement of colorable nuclear substance; *Z. K.*, granular detritus; *Sch.*, mucous membrane; *d.A.*, direct division of the nuclei, as if by ligature, ("Kernabschnürung"); *i.F.*, cells with indirect nuclear fragmentation—Polymorphous nuclei; *L*, leucocytes in the deeper layers of the mucosa and submucosa.

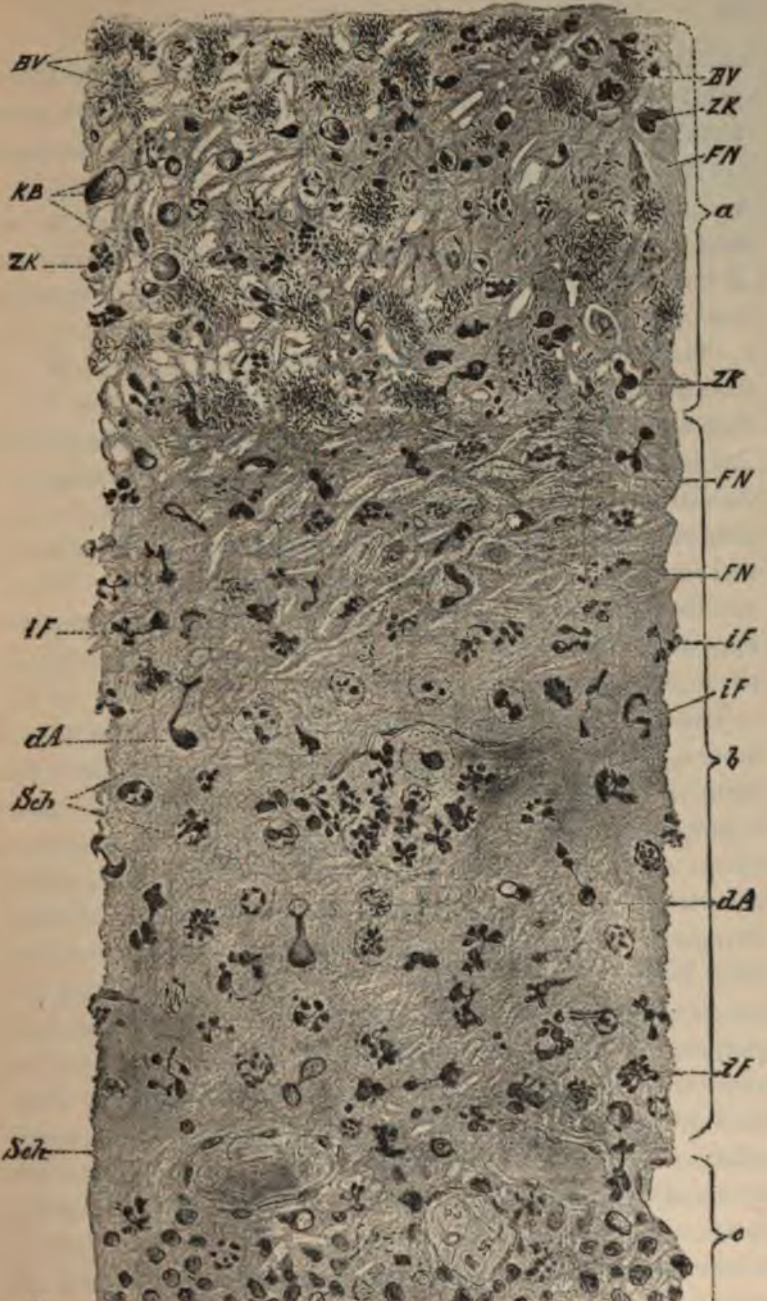

FIG. 8.—The Diphtheritic Process in the Mucous Membrane of the Pharynx and Uvula. (Oertel.) [See opposite page for explanation of Figure.]

This change is not a purely chemical one, but is also the result of the action of the serous and fibrogenous lymph which has exuded with the white corpuscles from the blood-vessels.

The coagulation of this substance upon a free surface or within the interstices of the mucous membrane or of the tissues beneath it, with an accompanying hyaline metamorphosis of cells, vessels and tissue-fibres, constitute false membrane, as has been already described.

The characteristic cell-changes referred to are seen not only in false membranes and the subjacent tissues in every situation, but also wherever the diphtheritic poison has penetrated, and in a degree proportioned to the directness and intensity of its action—in the tonsils and the lymphatic glands, and less uniformly and typically in more remote organs, as the stomach and intestines, the heart, the spleen, etc.

The absence of the characteristic lesions in the lungs is opposed to the hypothesis of a primary infection of the system through those organs.

The inauguration and extension of the diphtheritic process are described as taking place in the following manner: The diphtheritic virus irritates the epithelium and the uppermost layers beneath it, occasioning a profuse emigration of leucocytes. These cells, which have come as a protection, absorb the virus and become diseased, undergoing the necrobiotic changes which have just been described. Cells of various sizes press forward to take up the struggle with the invading poison—among them the large protoplasmic cells which are called phagocytes. Thick and dense layers of these cells form far under the epithelium and fill the whole mucosa, many of which show great alterations in their nuclei. These have undoubtedly taken up poison during or soon after their emigration from the blood-vessels, and have become diseased. They soon fall into a state of necrobiosis, and the result of these multiple necrobiotic processes and the irritation which they excite is the renewed accumulation of fresh cells, which in turn are exposed to the ever-increasing poison and are destroyed in great numbers. The formation of extensive necrobiotic masses or depots in and beneath the mucosa is the result of these occurrences.

In connection with the morbid appearances which accompany diphtheritic inflammation various kinds of bacteria have in many cases been observed on the surface of, and within, the false membranes and in the underlying tissues and vessels, as has been stated in the chapter on etiology.

The inflammatory processes which have been described occupy a various length of time in reaching their completion; the croupous sometimes does this by throwing out successive exudations, which produce distinct layers in the resulting false membrane. This membrane gradually becomes macerated and its filamentous attachments to the mucous membrane weakened by muco-purulent secretion beneath and around it, so that it becomes detached either in minute or larger portions.

The diphtheritic inflammation may terminate quickly with the production of a limited and superficial necrotic patch, or it may persist for some time, causing the death of deeper and deeper portions of the epithelial, the mucous and the sub-mucous tissues, the interpenetrating fibrinous network and bands being reinforced by repeated vascular exudations, and an intense purulent inflammation being excited in the subjacent and surrounding tissues. When the diphtheritic process has ceased, the patches or sloughs, as foreign bodies, keep up irritative inflammation beneath and around them. The superficial epithelial patches thus become infiltrated with pus and disintegrated or cast off, and the deeper sloughs are more tardily detached by suppuration and demarcative ulceration. In the former case the loss of epithelium is readily made good by the multiplication of the epithelial cells which remain; in the latter a cicatrix results which in time becomes covered with new epithelium.

In some cases the gangrenous form of necrosis is substituted for the diphtheritic by the penetration into the diseased tissues and the rapid multiplication in them of the bacteria of putrefaction.

Either of the forms of inflammation above described may occur on any mucous membrane. This fact shows that the occurrence of either is sometimes determined by the nature and intensity of its exciting cause independently of local anatomical conditions. Yet as a general rule the occurrence of one or the other form of inflammation is decided or greatly influenced by the anatomical peculiarities of the mucous membrane upon which it is developed.

The mucous membrane of the mouth, the pharynx and the œsophagus is covered with thick pavement epithelium which lies immediately upon the connective tissue of the mucosa without the intervention of a basement membrane. These conditions seem to favor the limitation in area of pseudo-membranous inflammation and its deep penetration, when it has once gained a foothold, rather than its rapid superficial extension and the throwing out of exudations upon the surface.

The epithelium of this region, when in a healthy state, is probably impermeable by bacteria. An exception to this condition has been demonstrated by Ph. Stöhr, in the case of the tonsils, the epithelia of which show minute cracks or loop-holes through which round cells emigrate, and through which, presumably, micro-organisms may find entrance—a fact which may in part explain the especial receptivity of these organs to the diphtheritic infection.

The oro-pharyngeal mucous membrane is in most parts abundantly supplied with blood-vessels and lymph-vessels, the latter of which empty into various glands in the neck and face, the principal exception being the tonsils, in which both are comparatively few. This peculiarity again may explain the fact that while tonsillar diphtheria is the commonest it is the least productive of general infection.

The mucous membrane of the nasal passages, except in the nostrils, and of the air passages, except on the true vocal cords and the aryteno-epiglottic fold, is covered with cylindrical epithelium. This is separated from the subepithelial tissues by a basement membrane which is their uppermost layer. These anatomical conditions favor the "croupous" form of inflammation.

"Croupous" and "diphtheritic" inflammation, as above described, do not always result from infection, but may be the effect of a variety of other causes. Among these causes are injuries from chemical, thermal and physical agencies.

In Guy's Hospital Reports for 1877 Dr. Hilton Fagge reported eleven cases of membranous laryngitis, with or without pharyngitis, which were directly caused by local injury to the throat, the injuries being scalds by hot water, the entrance of a foreign body into the trachea, a cut throat, and tracheotomy for various conditions. Dr. Fagge remarks upon these cases[1] that "they negative the *a priori* argument that the mucous membrane of the air-passages is not likely under simple (or non-specific) irritation to take on an inflammatory process attended with the formation of false membrane."

In the report last referred to (page 95) an interesting and instructive case is related which was communicated by Dr. Whitehead Reid. In the application of a bottle of eau-de-Cologne to the nostrils of a lady who had fainted, a portion of the liquid flowed through her left nostril into her throat. Symptoms of intense pharyngeal, nasal and laryngeal inflammation immediately followed. On the third day false membrane appeared in the pharynx and the left nostril. Pieces of membrane were several times coughed up. At length on the fifth day a perfect cast of the larynx, the trachea and the upper part of the left bronchus, was expelled entire with immediate relief to the vocal and respiratory symptoms, and the temperature soon fell below the normal. Small pieces of membrane continued to be coughed up, and membrane remained in the left nostril until the seventh day. The lady subsequently made a complete recovery. There was never any albumen in the urine; no paralysis followed. She had been exposed to no scarlatinal or other poison. There was no diphtheria in the village. Neither of her young children, who were constantly with her, became ill. On microscopic examination the constituents of the expelled cast were found to be identical with those usually found in croupous pseudo-membrane occurring in those localities.

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[1] Report of Committee of the Royal Med. and Chirurg. Society, 1878, on the relations of Membranous Croup and Diphtheria.

Many instances are on record of the production of croup-membrane in the throats and air-passages of horses and cattle by their inhaling smoke and heated air in burning stables.

Pseudo-membrane has been artificially produced in the trachea of animals by many experimenters by the application of various chemical irritants; by Bretonneau by means of tincture of cantharides and olive-oil, and subsequently by Trendelenberg, Oertel, Wood and Formad, Weigert and many others by the application of ammonia, corrosive sublimate, arsenic, chlorine, carbolic acid, etc. The pseudo-membranes thus produced have been found by most of the investigators referred to to be identical in all discoverable physical and chemical particulars with those ordinarily occurring in disease.

Dr. O. Heubner,[1] following the discovery of Cohnheim and Litten, that coagulative necrosis may be produced in a portion of mucous membrane by temporarily cutting off its blood-supply, selected as the most suitable one for his experiments, for anatomical reasons, that of the fundus of the urinary bladder of the rabbit. By ligating the neck of the organ the circulation was completely arrested. The ligature was removed after two hours, when the circulation was restored in those vessels which were free from thrombi. The result of the operation was, first, a swollen hæmorrhagic œdematous condition of the mucous membrane, the epithelium being loosened and its more superficial layers enlarged; and by the second and third day, in patches, a necrotic transformation of the epithelium, the mucous membrane and the submucous tissues into a firm yellowish layer which was morphologically identical with true diphtheritic membrane. The steps in this process are, first, necrotic changes in the cells and other constituents of the tissues, including lesions in the walls of the blood-vessels from inanition during the interruption of their blood-supply; second, the current being restored, inflammatory exudation through the dead and dying tissues, the result of the vascular lesions, the diphtheritic process being thus seen to be a nicely adjusted combination of necrosis and inflammation, in which the tissue elements must be dead or in process of dying, and the blood-vessels also injured but not yet dead or occluded.

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[1] Die Experimentelle Diphtherie. Leipzig, 1883.

The process of pseudo-membranous formation resulting from either of the causes just referred to seems to be an entirely local disease, and neither accompanied with constitutional poisoning nor communicable to others. Heubner found his diphtheritic products uninhabited by any bacteria except accidental ones, and they were inoculated into other animals without result.

The facts just referred to have an obvious bearing on the mooted question of the identity or diversity of membranous croup and diphtheria, or, more precisely stated, the question whether all cases of membranous croup are cases of diphtheria. They place it beyond doubt that pseudo-membranous croup, in the histological and anatomical sense of the term, is a condition which may be excited by a variety of causes, of which diphtheritic infection is only one.

In the clinical sense, however, as described by many authorities, simple membranous croup is a non-infectious phlegmasia of the laryngeal or the laryngo-tracheal mucous membrane, and is the result of meteorological conditions, which act upon it either as direct irritants or indirectly through the organism by the series of reflexes known as "catching cold." By far the more usual effect of this class of causes upon the mucous membranes is the production of catarrhal inflammation. That they should excite instead croupous inflammation in exceptional instances is explained by the supposed especial intensity of the irritation produced in those cases and by individual predisposition.

Testimony to the effect that not a few cases of pseudomembranous laryngitis have occurred, which were in no way traceable to diphtheritic or other infection, and followed exposure to cold, to cold and dampness, to sudden changes of temperature or to cold winds, which were accompanied with no evidence of constitutional diphtheritic poisoning nor communicated contagion to others, abounds in medical literature since the time of Home. Much of it, when examined by the light of our present knowledge of the diseases in question, must be rejected; but not a little remains which is so precise in character and from such competent sources that it cannot reasonably be doubted.

Statistics seem to show a much more direct etiological relation between meterological conditions and membranous croup than between them and diphtheria. In a large aggregate of fatal cases of membranous croup collected by Hirsch[1] the number occurring between October and March is to those occurring in the warmer half of the year nearly as two to one —a much larger ratio than that in the case of diphtheria, as shown in the chapter on etiology. The gross inaccuracy of the nosological classification in most such statistics must be conceded; but the difference referred to would probably be greater rather than less were they more accurate.

From the opposite point of view it is argued that some apparently typical cases of membranous croup prove to be cases of diphtheria by developing in their later stage, if they last long enough, the constitutional symptoms of diphtheria, and that others have been followed by cases of unquestionable diphtheria which were evidently due to their contagion; that the absence of diphtheritic constitutional poisoning in other cases may be due to their short duration before death is caused by asphyxia, and also to the fact that for anatomical reasons absorption of poison takes place much less readily from "croupous" inflammation in the larynx and trachea than from diphtheria in the pharynx or nares; that membranous laryngitis is of very frequent occurrence in connection with diphtheria, and is sometimes its initial manifestation, and that apparently typical cases of membranous croup occur with especial frequency in some epidemics of diphtheria.

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[1] Op. cit., p. 62.

The truth of all these statements and their force as arguments are unquestionable; yet it seems very doubtful if they can be made to apply to or to explain all of the cases originally referred to. Moreover, it seems a very probable supposition that a particular case of disease, occurring in places in which diphtheria is endemic or epidemic, or in which septic influences are present, may begin as a local non-infectious membranous croup and subsequently become infected by those agencies and thus converted into true diphtheria, since croupous inflammation must furnish an especially favorable soil for such infection. Again, the view that there is a membranous croup which is not due to diphtheria is strongly favored by the occurrence of the rare analogous affection, idiopathic, fibrinous or croupous bronchitis, which seems to be due to the causes of catarrhal bronchitis, *plus* an individual predisposition, and cannot be supposed to be, in all cases at least, a form of diphtheria.

Virchow, in 1885, restated to the Berlin Medical Society that he had never been able to admit that all cases of fibrinous laryngitis and tracheitis were due to diphtheritic poison.

A final answer to the question under consideration can only be the result of a fuller knowledge than we at present possess; but the facts which we have seem to me to establish a basis of strong probability for the following conclusions: Membranous croup, as above described, and diphtheria are two distinct affections. Simple membranous croup is a comparatively rare form of disease. In regions in which diphtheria is endemic or epidemic the two affections are so liable to be inter-complicated or confounded that the distinction is practically valueless.

In following the progress of diphtheria from local to general we have to note first the evidences of the entrance of poison from the seat of the local affection into the lymphatic and vascular systems. Penetrating the lymphatic vessels to the lymphatic glands, it produces inflammation in them, and this inflammation is to be observed in the glands which are thus directly connected with the part primarily affected. The glands are affected in various degrees, from a slight enlargement to an intense inflammation of the glandular structures themselves, and of the peri-glandular connective tissue. They are found on examination to be in a state of vascular engorgement and cellular hyperplasia, and the surrounding tissues œdematous and infiltrated with pus cells and occasional extravasations of blood.

The absorption of poison occurs mainly through the lymphatics, but evidently in some cases takes place through the capillary blood-vessels, as is evidenced by the fact that toxæmia is occasionally rapidly developed when there is little or no adenitis.

The blood is changed in color and in consistency in a considerable proportion of fatal cases. The cause and nature of these changes are not fully known. In a majority of instances the change is to a darker color and more fluid consistency than in health; in a smaller number it is to a brownish color and a turbid condition, in which it communicates a stain like sepia. After death from asphyxia the dark color may be due to an excess of carbonic acid. When it is the result of toxæmia it has been attributed in part to the *débris* of the disintegrated red corpuscles. A marked increase in the number of white corpuscles has been observed in some cases. There is also in the general disintegration of the constituents of the blood a diminution in the amount of fibrin.

Coagula are found in the cavities of the heart in many cases. These differ in form, size, structure, color and position. Some are said to have in these respects the distinguishing characteristics of ante-mortem clots.

Dr. Beverley Robinson,[1] as a result of many careful observations, regards these formations as a frequent cause of death. His observations are corroborated by others, as by W. C. Chaffey, M.B.,[2] who states that in twenty-three post-mortem examinations in diphtheritic cases made during the previous two and one half years at the Children's Hospital in Great Ormond Street, London, more than one half showed marked fibrinous deposits, "probably all ante-mortem." The great majority of authorities, however, including Cornil and Ranvier,[3] Sanné,[4] Cadet de Gassicourt,[5] and A. L. Loomis[6] believe that these coagula are not peculiar to diphtheria, but are formed under very various circumstances during the death agony, and are the effect rather than the cause of the cessation of cardiac action.

Coagula are also found in the large veins and sinuses. Hemorrhagic infarctions, the result of emboli, occur in many situations—in the subcutaneous connective tissue, beneath the pericardium, and in the muscular tissue of the heart, in the lungs, etc. Venous thromboses are seen in the substance of the brain and its investments, the liver, the spleen and other organs.

The heart is often healthy in appearance, but in some cases important changes are observed. Among these are the effects of myocarditis. The muscular fibres are found to have undergone granulo-fatty degeneration, and to have become of softish consistency and of a light brownish or grayish color, and to contain scattered extravasations of blood. These changes may be general or may be limited to a few fibres, and may occur in any portion of the heart-walls or in the columnæ carneæ. Their effect is, in proportion to their extent and their degree of advancement, to produce dilatation and weakness of the heart.

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[1] "Thése de Paris," 1872.

[2] British Medical Journal, July 16, 1887, p. 121.

[3] "Manuel d'histologie pathologique."

[4] Op. cit., p. 105.

[5] "Maladies de l'Enfance," t. iii.

[6] Medical News, Nov. 10, 1888, p. 539.

Endocarditis occurs in some cases of diphtheria as of other acute infectious diseases, but is not a frequent complication. It results in vegetations and fibrinous deposits on the valves, especially the upper surface of the mitral valve. These are easily detached and may become the sources of the widely distributed emboli already referred to.

The lungs are subject in diphtheria to a great variety of changes. These are mostly observed, however, in those cases in which death has resulted from croupal asphyxia. Among the morbid conditions which are most frequently met with are simple and pseudo-membranous bronchitis, broncho-pneumonia, pulmonary congestion and emphysema; more rarely lobar pneumonia, pulmonary œdema, pulmonary apoplexy, pulmonary gangrene.

Catarrhal bronchitis is in the majority of cases the accompaniment of laryngeal diphtheria, but is not infrequently associated with the pharyngeal and nasal forms.

Pseudo-membranous bronchitis in diphtheria is in nearly all cases the extension downward of the laryngo-tracheal affection, though in rare instances the bronchial tubes alone are affected.

Broncho-pneumonia, in its various forms and degrees, is of very great frequency in the laryngeal form of diphtheria, and is especially common in connection with bronchial diphtheria.

Pulmonary congestion is also very common in connection with laryngeal diphtheria, usually occupying the lower and posterior portion of one or both lungs; the upper and anterior portions are as frequently emphysematous.

The liver is usually unaltered, but is occasionally enlarged and congested or affected with waxy or fatty degeneration.

The spleen is usually normal, but may also be enlarged and softened.

The kidneys are the seat of the most frequent and important secondary changes occurring in diphtheria, but these changes are not peculiar or characteristic. The kidneys are affected in most cases which terminate fatally from systemic poisoning; and they exhibit every degree of affection from a slight hyperæmia to the most intense inflammation. The most usual form of nephritis in diphtheria is the parenchymatous, but the interstitial is not infrequent.

The brain, in cases in which death has resulted from croup, exhibits venous engorgement in its substance and its membranes and extravasations of blood—the results of asphyxia. Serous effusions of the meninges and into the ventricles, pus and lymph on the arachnoid membrane, or a granular condition of the white substance of the brain, have been observed in cases in which there had been grave septicæmia and albuminuria with cerebral symptoms.

In some observations after death from diphtheritic paralysis, no appreciable changes in the nervous system have been discovered. In some cases there have been various degrees of hyperæmia in the brain and spinal cord, with minute extravasations of blood, or in rare instances larger ones into their substance, and in some cases meningeal congestion with or without hemorrhages about the nerve roots.

The lesions which are characteristic of diphtheritic paralysis are only revealed by the microscope, and are found in the peripheral nerves which supply the parts affected, in the gray matter of the anterior cornua of the spinal cord, and in severe cases of long duration in muscular fibres, especially in the soft palate, but occasionally in the extremities.

The peripheral lesions were first observed by Charcot and

Vulpian[1] in a case of paralysis of the velum palati. Some of the muscular fibres in that organ were in a state of fatty degeneration. In the muscular nerves some of the fibres consisted of tubules emptied of their medullary substance. The neurilemma contained in some places numerous granular bodies with or without nuclei. Lorain and Lépine found similar changes in the soft palate, and Liouville in the phrenic nerves. Buhl[2] in one case found hemorrhages in the cerebral pia mater and cortex, infarcts in many parts of the brain and spinal cord, and the spinal ganglia and nerve-roots swollen, the swelling being due to infiltration of the nerve sheaths and the interstitial tissue with nuclear bodies which he considered characteristic of diphtheritic inflammation. Leyden found in one case appearances of a "neuritis migrans" ascending toward the nerve centres as far as the medulla oblongata; Oertel[3] in one case multiplication of nuclei in the gray substance of the spinal cord, especially in the anterior cornua, and hemorrhagic patches in the cord and pia mater; Vulpian[4] in three cases "rarefaction" of connective tissue in the anterior horns, with alterations in the motor nerve-cells and slight increase in the number of nuclei in the spinal cord; Pierret[5] in one case disseminated patches of spinal meningitis with peri-neuritis of nerve-roots.

Dejerine[6] found in five cases constant changes in the anterior cornua with consecutive neuritis of the corresponding anterior spinal nerve-roots. The affected nerve cells were swollen in some instances, in others shrunken, were indistinct, had lost their processes and were globular in shape. The number of nerve-cells in certain portions of the anterior cornua was diminished. The small vessels were distended with blood and dilated, and hemorrhages from their rupture were observed in the anterior cornua together with perivascular collections of small cells. Around the central canal there was cell-infiltration of an inflammatory nature. Dejerine regarded this affection of the spinal cord as subacute tephro-myelitis, the accompanying neuritis of the anterior spinal roots being secondary to the spinal lesion.

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[1] Compt. rend. de la Soc. de Biol., 1862.

[2] Zeitsch. f. Biol., 1867.

[3] Deutsches Arch. f. Klin. Med., viii., 1871.

[4] Malad de Syst. Nerv., 1870.

[5] Compt. rend. de la Soc. de Biol., 1876.

[6] Arch. de Phys. norm. et path., t. v., p. 107, 1878.

Gaucher[1] in one case found changes in the anterior cornua and nerve-roots identical with those described by Dejerine. Abercrombie[2] in seven cases, Percy Kidd[3] in one case, and Dr. Mott of Liverpool, as reported by Percy Kidd, in one case, in which only the brain and spinal cord were examined, also found similar lesions in the latter to those described by Dejerine. Meyer[4] in one case found inflammatory changes in the gray matter of the anterior and posterior cornua of the spinal cord, degeneration of spinal roots and neuritis in phrenic and muscular nerves. Pitres[5] in one case found parenchymatous neuritis of the peripheral nerves and spinal roots with no alteration in the spinal cord. Mendel[6] in one case found marked congestion of small arteries of the brain; capillary hemorrhages in pons, medulla, and near the nucleus of the oculo-motor nerve; neuritis of peripheral nerves, especially the oculomotor, abducens, and vagus.

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[1] Journ. de l'anatom. de Robin, 1881.

[2] Trans. Internat. Med. Cong., 1881.

[3] Med. Chir. Trans., lxvi., 1885, p. 136.

[4] Virch. Archiv., vol. lxxxv., p. 181.

[5] Arch. de. Neurol., 1886, xi., p. 337.

[6] Berliner Klin. Wochenschr., 12, 1885.

CHAPTER IV.

SYMPTOMS.

DIPHTHERIA is classed according to its localization as pharyngeal, nasal, laryngeal, ocular, vulvar, cutaneous, etc.

According to its intensity, as mild, severe and malignant.

According to the degree of toxic absorption, as benign and septic.

According as it is idiopathic or supervenes upon other diseases, as primary or secondary.

Diphtheria has many complications. These may be mainly due either to the mechanical interference of the false membrane with respiration; as is seen in certain pulmonary complications of diphtheritic croup, or to hæmic poisoning, as is seen in the morbid affections of the kidneys, the heart and other organs.

Diphtheria has also certain sequelæ, the most important and characteristic of which is paralysis.

DIPHTHERIA OF THE PHARYNX AND SOFT PALATE.

The pharynx is by far the most usual site of diphtheritic inflammation. Not only are a large majority of all diphtheritic attacks limited to this locality, but in a great proportion of all cases in which the larynx, the nasal passages or the mouth are invaded, the pharynx is also affected either primarily or secondarily.

No portion of the pharynx is so often affected as the tonsils. In thirty-eight cases accurately described by me,[1] the location of diphtheritic membrane was as follows: tonsils only, 11; tonsils and velum palati, 3; tonsils and nares, 4; tonsils, soft palate and nares, 8; tonsils and tongue, 1; tonsils, nares, uvula and gums, 1; tonsils, nares, soft palate and tongue, 1; tonsils, nares, soft palate, tongue and lips, 1; tonsils and larynx, 1; tonsils, soft palate and larynx, 4; uvula, 1; velum, 1; uvula and nares, 1; showing the tonsils to have been affected in thirty-five out of thirty-eight cases. From my observation of much larger numbers of cases of which my records are less complete, I think that this distribution is about an average one, except that in some epidemics the proportion of laryngeal cases would be much greater.

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[1] New York Med. Record, March 27th, 1880, p. 340.

THE CATARRHAL STAGE.

The symptoms of the initial stage of pharyngeal diphtheria differ in no respect from those of the same stage of other forms of sore throat. As in them, there may be for a period varying from a few hours to several days feelings of depression, slight chilliness, feverishness, anorexia, nausea, headache, slight pains in the neck, back or extremities. A pronounced chill is less usual, but sometimes occurs. In children of highly susceptible nervous organization there may be convulsions.

The temperature is elevated from one to several degrees, and the pulse is correspondingly accelerated.

At this stage of the disease, and as its first noticeable symptom, there are often pain and difficulty in swallowing, but sometimes there is an entire absence of subjective throat symptoms.

If the throat be inspected, however, it will invariably be found to be more or less reddened and congested. This appearance may be general, but more usually is limited or unequal, affecting especially one tonsil and its immediate surroundings, or one of the faucial arches and the uvula, or a well-defined patch on the anterior surface of the soft palate.

THE STAGE OF PSEUDO-MEMBRANOUS FORMATION.

The transition from the catarrhal stage to the croupous or the diphtheritic, when watched, is seen to consist in a gradual deepening of the angry redness in one or more patches of the mucous membrane, and then the appearance upon them of dots or streaks of a pearly or yellowish whiteness. These multiply, extend and coalesce over the affected surface until it is covered with a smooth, glistening layer ("croupous"), the margin of which is surrounded with a red or purplish ring. Or yellowish spots appear on the surface of the mucous membrane, and then become more and more definite and opaque, until their aggregation assumes the appearance of a patch of yellow or gray chamois leather imbedded in the intensely inflamed tissues ("diphtheritic"). The exudative deposit or the necrotic change thus occurring may soon reach its completion, with a moderate degree of surrounding inflammation and febrile disturbance, or with a persistence and intensification of both it may continue to extend by an enlargement of the patches already formed, or the appearance of additional ones.

The pain in the throat is sometimes so slight that the real nature of the ailment is unsuspected until it is revealed by inspection; but it more usually varies from a sense of stiffness or pricking to a most acute distress on swallowing.

Vomiting is a frequent symptom, and at this stage of the disease is usually a reflex from the faucial irritation, as when the throat is tickled with a feather. I have seen it to be particularly liable to occur when the uvula is the seat of diphtheritic inflammation.

The throat is filled with mucus, which, at first white and tenacious, becomes more and more purulent and sometimes reddish or streaked with blood from hemorrhagic points in the inflamed mucous membrane.

Fœtor in the breath, slight at first, becomes more and more noticeable.

Adenitis may be so slight as to be scarcely perceptible, or may rapidly become a prominent and formidable symptom.

The temperature is now at its highest, and may vary from an elevation of one or two degrees above the normal to 105° or 106° F. It is usually in direct proportion to the intensity of the inflammation in the mucous membranes, the sub-mucous tissues and the glands.

The acceleration of the pulse at this stage of the disease is usually in proportion to the rise in temperature, and sometimes exceeds that proportion. There are in some cases other qualities to be noted besides its rapidity. It may be small, thready, irregular or flickering. This is usually in cases in which there is a rapid onset of throat inflammation and adenitis, with acute faucial pain and reflex nausea and vomiting. It is then the pulse of shock. The abundant nerve supply in the throat causes it to be the source, when irritated, of various remote reflex disturbances, and these may include the action of the heart. This point is important, because this quality of the pulse at this stage of the disease is often attributed to the essentially weakening effect of diphtheria, and therefore supposed to call for early and profuse stimulation. That this is not usually the case is proved by the fact, which I have often observed, that after the extension of inflammation has ceased and the attending pain and nerve disturbance have abated the pulse returns to nearly its normal volume and regularity, although the process of constitutional poisoning peculiar to the disease may then have really commenced or become more advanced than before.

The character of the disease at this stage is usually sthenic, though some of its symptoms may, as has just been pointed out, apparently indicate asthenia. Its essential feature is progressive diphtheritic inflammation. Upon the extent and intensity of this inflammation depend not only the accompanying symptoms, but in most cases the subsequent type and gravity of the malady.

Mild or Benign Form.—In this form the symptoms which have now been referred to are relatively moderate in degree and transient in duration. The temperature rarely exceeds 104° F.; adenitis is slight; the swelling of the throat is not very marked, though the tonsils may be considerably enlarged. The false membrane is often limited to the tonsils, though it not infrequently covers more or less of the surface of the faucial pillars, the soft palate and the uvula. Its character is distinctive, being invariably comparatively superficial.

Severe Form.—In this form, on the other hand, the symptoms are usually correspondingly grave. The temperature may reach 105° or 106° F.; adenitis is commonly quite marked, and may be very great. The inflammation in the throat is more intense than in the other form, the swelling being greater, the redness of the mucous membrane deeper, and the false membrane usually, though not necessarily, more extensive—sometimes covering the entire pharynx and soft palate in one nearly continuous investment. Its character is also distinctive. Some portion of it, at least, is of the deep or parenchymatous variety.

FURTHER COURSE OF THE DISEASE AND ITS TERMINATIONS.

When the diphtheritic inflammation has reached its acme —usually from the second to the fourth day of the disease— the predominant symptoms undergo a change in two respects: There is, first, a subsidence of the febrile symptoms to the milder ones of a subacute inflammation which is mainly due to lesions already produced; and, second, the first appearance in some cases, and a notable increase in others of symptoms which denote constitutional infection.

Mild or Benign Form.—This has two modes of termination. Usually it is favorable. The faucial inflammation and the fever subside and do not return. The false membrane exfoliates after from three to seven days' continuance, when the mucous membrane is seen to be only slightly hyperæmic, and soon recovers its normal appearance. In rarer cases the disease, after continuing for some days in this form, suddenly, either from injudicious treatment or exposure to cold, or some cause which is not so obvious, takes on a new aspect—the diphtheritic inflammation becoming not only more extensive but more intense and deeper—and assumes the form next to be described.

Severe Form.—In this form of the disease the more superficial portions of the false membrane may exfoliate in a few days as in the milder form; but the deeper portions, sometimes very extensive, and sometimes only a single limited patch, continue after the rest has disappeared, impenetrable to ordinary antiseptic remedies, and causing far greater local irritation and more profound constitutional poisoning than that has done.

Nasal and oral diphtheria are very frequent complications, and add materially to the gravity of the disease. These will therefore now be described.

NASAL DIPHTHERIA.

Nasal diphtheria is most usually secondary to pharyngeal diphtheria, making its appearance after the affection in the throat has existed for one or more days; yet in many cases it is primary, preceding the other or appearing at the same time with it. In some cases the disease is limited to the nasal passages throughout its course.

When the affection begins too high up for the false membrane to be visible on inspection, its nature may be for a time uncertain, but it is usually soon recognizable by the degree of obstruction which it causes and by the character of the discharge from the nostrils. This becomes either thin and ichorous, or profuse, yellowish and muco-purulent. It is often very irritating, producing excoriation on the margins of the nostrils and the upper lip, which become coated with diphtheritic membrane. There is also quite early a characteristic fœtor.

Epistaxis often occurs. This may result from capillary congestion or commencing ulceration, and may follow picking or rubbing the nose or maladroitness in administering injections, etc. It is then usually slight or easily controllable. Later it may result from more extensive ulceration of the mucous membrane or from a hæmorrhagic tendency consequent upon the constitutional poisoning, and is then profuse, persistent and difficult to control. I have never known of its being the immediate cause of death, but the serious exsanguination which it produces when the system is already anæmic and enfeebled is doubtless in some cases the determining cause of a fatal result.

The chief importance and gravity of nasal diphtheria, however, results from the fact that it is especially liable to be attended with constitutional poisoning by absorption. This results from two causes: first, the Schneiderian membrane is abundantly supplied with absorbent vessels by means of which the poison is conveyed into the general circulation; and second, while the throat is washed by the saliva and by food and drink as well as medicines which are swallowed, there is no such provision of nature for the disinfection of the nasal passages.

As a result of this toxic absorption adenitis is a usual accompaniment of nasal diphtheria. Yet in some grave cases adenitis is only very slight.

I have already stated that in rare cases diphtheria is limited to the nasal passages. When the posterior nares only are thus affected the nature of the disease is liable to be overlooked. Its presence may be suspected from the existence of symptoms of diphtheritic poisoning with those of post-nasal catarrh.

DIPHTHERIA OF THE MOUTH.

Diphtheria of the mouth is usually a complication of pharyngeal diphtheria. It often alights on points where abrasion of the epithelium or ulceration exists. In a case in which a too energetic nurse persisted, in spite of my remonstrances, in removing the secretions from the mouth of an infant suffering with diphtheria by wiping it out with a napkin, diphtheritic patches appeared on the tongue and the lips. In some instances, however, the mouth is the only region affected. Its most usual situation is the lips—either the angle at their junction or the inside of the lower lip. In such cases the lip sometimes becomes greatly swollen. Next in frequency to the lip diphtheria occurs on the tongue. In that situation it may be superficial and of transient duration, or deep and persistent and accompanied with great swelling. It occurs also on the gums and on the mucous membrane lining the cheeks. In those localities also it may be of very various degrees of depth, extent, severity and persistency, and attended with various degrees of constitutional poisoning.

CONSTITUTIONAL OR SEPTIC DIPHTHERIA.

In the form of diphtheria now under consideration—namely, the severe form of pharyngeal diphtheria with or without the complications just referred to—constitutional poisoning in a greater or less degree is invariably present, and, in the absence of laryngeal diphtheria, is the chief source of danger.

Among the earliest symptoms of this condition is cachectic pallor, the flush of fever being gradually replaced by an ashen or sallow tinge. The eye loses its brightness and the expression of the countenance becomes dull and apathetic. There is often marked drowsiness.

The impoverished and poisonous blood-condition reacts upon the local inflammation itself. It becomes less acute and is attended with less pain. If it continues to extend it does so more slowly and insidiously. The pseudo-membrane loses its smoothness and whiteness and becomes sodden in appearance and of a dingy gray, or is dark-colored from capillary hæmorrhages beneath and around it. The mucous membrane around its margin becomes paler or more livid, and is flaccid or œdematous. The secretions are ichorous or sanious, and very fœtid. It is not strange that the symptoms in bad cases should have impressed the earlier observers with the belief that the process they beheld was one of gangrenous disorganization.

It is important to remark, however, that grave and fatal poisoning may take place in diphtheria without any such striking evidences of putrefactive changes in the throat. The system may be rapidly infected from a limited diphtheritic area in the nasal passages, or from beneath a small and apparently trivial membranous patch in the throat, if that patch penetrates the mucous membrane and its under surface is in relation with absorbent vessels, though itself may remain unchanged. The view presented by some authorities, that the occurrence of septic poisoning in diphtheria depends upon putrefactive decomposition of diphtheritic membrane, is a dangerous error. The pseudo-membrane is rather a covering beneath which the septic processes which are peculiar to the disease may go on undisturbed and their products may accumulate for absorption and dissemination. The more advanced these processes are, however, and the more abundant their products, the greater is, of course, the liability to such dissemination.

All the symptoms now manifest a progressive tendency to asthenia. The fever usually gradually abates. The temperature, as a rule, declines to a moderate elevation above the normal, or sometimes even falls to 97° or 96½° F., though in exceptional cases hyperpyrexia is marked and persistent. The pulse becomes weaker and is often irregular. It is easily disturbed by any slight exertion or excitement. Digestion is feeble. There is indifference and often aversion to food and drink, and if they are forced upon the patient nausea and vomiting result.

In this form of diphtheria there is almost always albuminuria, and frequently grave implication of the kidneys. These will be separately considered.

Delirium sometimes occurs, but is infrequent.

When this form of the disease terminates fatally it is usually in the course of the second week—that is, from the eighth to the fourteenth day. Death most frequently follows a gradual failure of the vital forces caused by the progressive impoverishment and poisoning of the blood, or, in other words, results from exhaustion and asthenia. The most notable preceding symptom is usually the progressive weakness of the circulation as manifested in the pulse and the heart-sounds, pallor, cold clammy perspirations, coldness of the extremities, etc. Sometimes there is a rapid development of the signs of pulmonary œdema. In rare instances there are symptoms of grave cerebral implication. Quite often death occurs suddenly and more or less unexpectedly by heart-failure after some slight excitement or exertion—in some instances after merely sitting up in bed—as a result of cardiac paralysis or the weakening of the heart by myocardial degeneration. Death by this mode takes place not merely during the continuance of the diphtheritic affection, but in some instances weeks after its cessation, and when good progress has been supposed to have been made in recovering from its effects.

When recovery takes place it is usually slow and gradual in proportion to the degree of hæmic impoverishment and disorganization and of tissue degeneration. The pseudo-membrane and the nasal discharge rarely disappear before the tenth or twelfth day of the disease. Even before that event there is in some cases a mitigation in the constitutional symptoms. In other cases they continue unabated until it occurs and then improve with striking rapidity, showing their direct dependence on the causes just referred to.

Sometimes after a few hours or a day or two of such improvement there is a return of febrile symptoms, and the pseudo-membrane which has nearly or quite disappeared is replaced by a new formation accompanied with a renewal or intensification of the toxæmia, and causing another period of anxiety and danger lasting from five to ten days, the second formation of membrane being seldom quite as deep or persistent as its predecessor. In rare cases, when the patient has survived this relapse, it is followed by a second of shorter continuance, so that the whole duration of membranous disease is from three to four weeks.

In occasional instances the membranous formation is white, not very tough nor very deep nor very thick, but evidently consists of a transformation of the superficial epithelium, or, in other words, is of the variety described as "superficial diphtheria." It is closely adherent to the mucous membrane and never exfoliates in large pieces. It is often located on the anterior side of the soft palate, or around the uvula, or on the posterior side of the soft palate, or less frequently on the posterior wall of the pharynx. Without ever completely disappearing this membranous affection sometimes diminishes and sometimes extends, with only moderate inflammation and fever, but with marked pallor, cachexia and constitutional depression, persisting altogether from two to four weeks. I have seen several such cases in children and two in adults, one of whom was seventy years of age. In the last mentioned case the temperature varied between 96⅗° and 98° F. for nine days, being usually below 97½°; the whole duration of membranous disease being four weeks. All these cases terminated favorably.

In many cases a prolonged and critical period of weakness follows the final disappearance of the membranous affection. There may be relaxation and catarrh of the upper air-passages; albumin may persist in the urine for weeks or even months, and the heart's action may be feeble and irregular.

In many other cases, including some very severe ones, the restoration of the patient to complete health and strength is surprisingly rapid, all traces of the illness being often obliterated in the course of a few weeks.

The symptoms attending convalescence, whether it be rapid or slow, and whether it follow a mild or a grave form of the disease, are often complicated by the occurrence of paralysis.

MALIGNANT DIPHTHERIA.

The term malignant is by some applied indiscriminately to all the graver forms of diphtheria in which there are marked evidences of constitutional poisoning, but may more conveniently be reserved to designate in diphtheria, as in scarlatina, that class of cases which are characterized by exceptional earliness and intensity in the systemic poisoning and by such rapidity in the course of the disease that the distinctive features of its several stages are confused together and unrecognizable. For this reason they often seem mysterious and inexplicable by the laws which apply to the ordinary forms of the malady.

There are two kinds of malignant diphtheria, the violent and the insidious. The former differs from a form of severe diphtheria which has already been described, only as the tornado differs from the ordinary storm. A brief period of rigors, vomiting or convulsions is accompanied or succeeded by a rapid development of intense and extensive inflammation in the throat and the nasal passages, extreme adenitis and a high fever, the temperature reaching 105°, 106° or 107° F., and the pulse being so rapid that it can hardly be counted. Deep, thick, gray, false membrane soon overspreads the whole pharyngeal region, the vault of the palate and sometimes the dorsum of the tongue, and obstructs the nasal passages. There is discharge from the nostrils and marked fœtor. Sometimes gangrenous complications occurs. In other cases the diphtheritic membrane in the throat is not so extensive, but there is a general purplish redness with œdematous swelling which resembles phlegmonous erysipelas.

There is almost from the first an expression of dullness and apathy, which in some cases soon deepens into delirium or coma. In some cases the fever continues high until the fatal termination, which may take place on the third or fourth day. In other cases it partially subsides, and the adynamic symptoms of septic poisoning and hæmic disorganization already described predominate. Hæmorrhages occur from the nasal or other mucous surfaces, and petechiæ appear on the skin. Symptoms of grave renal or cerebral implication appear. Death takes place on the third to the seventh day.

The insidious form of malignant diphtheria begins with only a moderate degree of febrile disturbance, and the membranous affection in the throat is of limited extent. There is nasal diphtheria, but this may be limited to the post-nasal region, where it may be undetected. Marked pallor, depression and somnolence almost from the first indicate an overwhelming constitutional poisoning, from the effects of which and with the symptoms already described, the patient rapidly sinks, and dies from the third to the seventh day of the disease.

Malignant diphtheria is, happily, in proportion to the whole number of cases of the disease, only exceptional. It occurs with especial frequency in some epidemics, and in the earlier rather than the later part of their course. Yet sporadic cases are now and then malignant. There seems to be in some individuals and in some families a predisposition to grave forms of diphtheria, as is also the case in regard to scarlatina. From the circumstances under which such forms of the disease occur, and from facts which are elsewhere stated, it is probable that they are the result of two factors—first, a contagium of especial virulence, and, second, the early penetration into the body of septic organisms.

Previously impaired vitality or blood contamination from insanitary conditions may not infrequently enter into the explanation of the more "insidious" cases.

GANGRENE.

Though the belief of the older writers that diphtheria is a gangrenous affection has been found to be erroneous, the two morbid conditions being distinct, yet gangrene does occur in a small proportion of cases in connection with, and as a result of, diphtheria.

Gangrene occurs in those forms of diphtheria in which the inflammation is intense and the infiltration is deep. A greater or less portion of tissue dies and sloughs away. Yet it does not occur in all such cases, nor, as a rule, in the worst ones. In many fatal cases in which these conditions are most marked there is no gangrene, and, per contra, some cases recover in which there has been considerable destruction of tissue by gangrene, the diphtheritic affection not having been especially formidable. It is also to be noted that gangrene in diphtheria does not depend on the amount of the constitutional poisoning, for in many of the most malignant toxic cases gangrene is absent, and I have seen it in several cases in which blood-poisoning was not especially pronounced.

Gangrene may accompany diphtheria in almost any situation, but does so most frequently on the soft palate. The entire uvula or one of the palatal arches sometimes sloughs away and occasionally the soft palate is perforated. Gangrene does occur on the tonsils, though rarely. It should by no means be associated with the gaping cavities sometimes seen in them after the pseudo-diphtheria which accompanies follicular tonsillitis, in which there is usually no actual loss of tissue. I have seen gangrene in diphtheritic patches on the inside of the cheeks. It sometimes occurs on the lip and in cutaneous and vulvar diphtheria, etc.

Destructive as the gangrenous process in diphtheria sometimes appears, yet as a rule the actual amount of deformity which remains after cicatrization is comparatively slight.

LARYNGEAL DIPHTHERIA.

Laryngeal diphtheria, or diphtheritic croup, is in the majority of cases the result of the extension of the disease downward from the pharynx; but in not a few cases it occurs first in the larynx and later makes its appearance in the pharynx, while in some instances it never extends above the larynx. Extension from the pharynx most frequently occurs within the first four or five days of the disease, being comparatively rare at a later stage. Its presence is then made known by the gradual addition of the symptoms of croup to those of the faucial affection.

The amount of febrile and nervous disturbance that attends the onset of primary laryngeal diphtheria is very various, being sometimes considerable and in other cases remarkably slight. The first distinctive symptoms of its occurrence are those of laryngeal inflammation and irritation. There is usually a characteristic cough, which may be harsh, dry and somewhat shrill or hoarse and muffled. It is usually, though not always, attended with pain. The voice is altered, being roughened and husky or weakened and indistinct, and speaking and crying are often painful. The respiration is not usually at first affected. As the disease progresses the symptoms of laryngeal stenosis become more marked. The cough is hoarse and metallic, the voice raucous or whispering, and the respiration is more and more obstructed in both acts, inspiration especially being labored, prolonged and stridulous, and accompanied with depression above the sternum and clavicles, in the intercostal spaces and over the diaphragm.

In the earlier stage of the affection these symptoms are usually intermittent or variable, being increased by the presence of mucus in the larynx, or excited by crying and struggling, there being a tendency in this, as in other forms of laryngitis, to more or less spasmodic tightening from time to time. As the disease progresses and stenosis increases they become more constant.

The subsequent course of the malady varies greatly in different cases. In some, which are unfortunately but a small proportion of all, the croupous exudation in the larynx is only a thin pellicle, the accompanying tumefaction is not very great and the spasmodic closures not very severe or persistent. The dyspnœa and other symptoms of the affection may persist for a period varying from four or five to eight or ten days, varying in intensity but never entirely intermitting on the one hand, nor, on the other, becoming so severe as to entirely prevent respiration. At length the membrane exfoliates, the inflammation subsides, and the symptoms of obstruction disappear, either quite suddenly or gradually.

In the large majority of cases, however, the affection has a malign, and often a treacherous character, which fully justifies the dread in which it is universally held. Not infrequently, after pursuing for some days a mild course such as has just been described, or even apparently abating in severity, from some slight exposure to cold, or often without any evident explanation, there is an aggravation of all the symptoms so rapid that almost before its seriousness is realized death occurs from asphyxia.

In other cases the course of the affection is from the first steadily from bad to worse. The rapidity may be so great that fatal laryngeal occlusion shall take place within twenty-four hours from the commencement of the croupal symptoms —a possibility most important to be realized. It occurs still more frequently on the second day and the succeeding ones up to the fifth, and then with diminishing frequency up to the tenth or twelfth, or in rare cases even a later one.

As this event approaches the gravity of the symptoms becomes painfully apparent to the most inexperienced beholder. The cough is muffled and abortive. The voice is suppressed to a hoarse whisper. The breathing is stridulous and labored in both acts, inspiration being especially prolonged, and the accompanying depressions in the supra-clavicular and other spaces being very marked. The patient, if a child, either sits up constantly or starts up frequently, turning appealingly to his parents or nurse for relief, or throws himself violently about in his frantic efforts to get breath, his countenance expressing alarm and distress, the hue cyanotic.

These symptoms are often accompanied with the evidences of blood-poisoning which have previously been described. This is likely to be the case in proportion to the time the disease has continued, and to the amount of the accompanying pharyngeal and nasal affection.

Death in laryngeal diphtheria results from asphyxia caused by the occlusion of the laryngeal aperture by pseudo-membrane, by tumefaction of the mucous membrane, by spasm, by œdema of the glottis, or by a flap of partially detached false membrane acting as a valve, or from the effects of the extension of the membranous affection downward through the bronchial tubes.

The character and course of the symptoms vary very much according to the age of the patient, the tendency to laryngeal stenosis being greater the younger he is, from the fact that the laryngeal aperture is both absolutely and relatively smaller in children than in adults, and in young children than in older ones.

Although the mode of termination just sketched is unfortunately that of the great majority of cases of laryngeal diphtheria in which operative measures are not employed, yet there are exceptional recoveries which prove that no case is absolutely hopeless unless it is made so by complications. Sometimes when death by asphyxia seems imminent the obstructing false membrane is opportunely coughed up. I have known of several striking instances in which life has been thus saved almost at the last moment.

Tracheal and Bronchial Diphtheria.

Diphtheria of the trachea and the bronchial tubes is usually the result of the extension downward of the disease from the larynx, though in some cases it occurs without any implication of the larynx in connection with pharyngeal or nasal diphtheria. It is a very common accompaniment of laryngeal diphtheria, and is the most frequent cause of the failure of tracheotomy or intubation to avert a fatal issue. In some instances it extends through the bronchial tubes to their ultimate ramifications and into the air-cells themselves.

The pseudo-membrane in these localities is of the kind described as "croupous," lying loosely upon the mucous membrane. It is of various degrees of thickness and is usually of not very firm consistency.

Among the most usual results of tracheo-bronchial diphtheria are broncho-pneumonia and pulmonary collapse. Its symptoms are those of bronchitis with marked dyspnœa and cyanosis, which are frequently complicated by those of the affections just mentioned. Owing to the dyspnœa caused by the laryngeal affection, the physical signs of tracheal and bronchial diphtheria are obscure and indistinct. Its presence is in rare cases made a certainty during life by the coughing up of membranous casts of the bronchial tubes.

Diphtheria of the Ear.

Diphtheria of the Eustachian tubes, the tympanum and the external ear is usually the result of the extension of the disease to those parts from the pharynx. The symptoms are those of ordinary otitis media, with the addition of diphtheritic exudation. This lines the Eustachian tubes, follows the suppurative inflammation through the cava tympani, and after perforation of the drum overspreads the wall of the meatus externa and sometimes the adjacent cutaneous surfaces. In the middle ear diphtheritic otitis is usually very destructive, hearing being permanently impaired or destroyed.

Diphtheritic otitis media rarely, if ever, occurs in the course of primary diphtheria. It has been observed in the diphtheria which follows small-pox and some other diseases, but in the great majority of all cases is a complication or sequela of scarlatina. So uniform, according to my experience, is this relation of the two diseases, that I long ago learned to regard the occurrence of otitis in connection with diphtheria as strong presumptive evidence that the diphtheria was of scarlatinal origin. In a number of such cases in which that origin had not been recognized, I have learned, on carefully tracing back their early history, that there had been characteristic symptoms of scarlatina, though so slight and so transient as to have been disregarded. Several of these cases have been seen by me in consultation with other physicians, who have been convinced of their scarlatinal origin by a careful consideration of evidences which had previously escaped their notice or been regarded as inconclusive.

Diphtheria of the meatus externa not resulting from otitis media has been observed in rare cases. It has usually, at least, supervened upon a catarrhal affection of the part

DIPHTHERIA OF THE EYE.

Diphtheritic conjunctivitis may occur as a primary affection or may supervene upon purulent conjunctivitis. It is also in rare cases consecutive to nasal diphtheria by extension through the lachrymal duct.

It varies very much in intensity, being sometimes a comparatively mild and limited affection, but more often very severe and destructive to the eye.

It begins more usually upon the palpebral conjunctiva. The diphtheritic exudation is sometimes in thin patches which cannot easily be detached; in other cases it is thick, gray and coherent, and can be stripped off in large pieces.

When the affection is primary and severe it is attended with great swelling, heat, pain and sensitiveness in the eyelids. The conjunctiva, at first red and vascular, is later dry, smooth and of a grayish yellow. This is the result of the dense infiltration of its substance, which compresses the blood-vessels and checks the circulation. Numerous extravasations of blood may be seen upon it. This dense infiltration in the chemosed ocular conjunctiva strangulates the blood-vessels which supply the cornea and thus greatly interferes with its nutrition; hence the cornea is very liable to undergo ulceration, suppuration and perforation. The earlier in the course of the affection this ulceration occurs the more extensive and destructive it is likely to be.

After a few days the conjunctiva becomes less tense and hard and more moist and vascular, and there is a copious purulent discharge. The membranous exudations become softened and loosened, and finally are detached, but relapses are very liable to occur.

Diphtheritic conjunctivitis may be limited to one eye, but in most cases affects both. Its discharge is exceedingly contagious. It is not a very common affection, but it sometimes occurs epidemically. It is much less common in this country than in some parts of Europe. Dr. W. O. Moore informs me that in the records of the New York Eye and Ear Infirmary for fifteen years but two cases of ocular diphtheria appear.

DIPHTHERIA OF THE ŒSOPHAGUS, STOMACH AND INTESTINES.

Diphtheria of the Œsophagus is very rare and is usually secondary to other diseases.

The symptoms of œsophageal diphtheria are not distinctive. They would of course be expected to be pain, dysphagia, choking sensations, vomiting, reflex cough, etc. Yet these symptoms have been absent in cases in which the autopsy revealed the existence of the affection, and have been present in many cases in which no such condition existed. In a majority of the cases in which it has occurred its presence has been unsuspected until discovered at the autopsy. Hence its diagnosis is in a large proportion of cases difficult or impossible. This obscurity is characteristic of œsophageal affections in general. Of forty-four cases reported by Steffen,[1] including diphtheria, catarrhal inflammation, ulceration, gangrene, etc., as shown at the autopsy, the diagnosis had been made in only three.

Cicatricial stricture of the œsophagus has in a few cases occurred as a sequel of diphtheritic ulceration.

Diphtheria of the stomach is also a rare affection, and its symptoms are necessarily obscure. It has been found in some autopsies affecting either limited portions of the gastric mucous membrane or, in a few instances, nearly its entire surface.

Diphtheritic inflammation of the mucous membrane of the small and the large intestine has also occurred. Its existence has in a few instances been made known during life by the passing of membranous casts of the bowel, but in most cases has only been revealed at the autopsy.

Diphtheria of the anus has been observed in quite a number of instances, sometimes extending upward into the rectum or over the adjoining skin.

DIPHTHERIA OF THE GENITO-URINARY ORGANS.

Diphtheria has occurred in the urinary bladder in chronic cystitis and in connection with stone in the bladder, and also following various surgical operations on that organ. It has also invaded the uterus as a puerperal complication and after surgical operations. It sometimes occurs in the vagina under the same circumstances.

Diphtheria of the vulva is a not infrequent form of the disease. It usually occurs during the endemic or epidemic prevalence of the pharyngeal affection, sometimes as a complication in the same patient, and sometimes in others who have been exposed to the contagion of the disease. There is usually some accompanying inguinal adenitis, but this may be slight or absent. The affection sometimes extends over the adjoining skin, and in rare cases involves both the vulva and the anus with the region between them.

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[1] Quoted by Dr. H. D. Fry, in a valuable and exhaustive article on this subject, Am. Jour. Med. Sc., October, 1885.

DIPHTHERIA OF THE SKIN AND OF WOUNDS.

That diphtheria shall affect the skin it is necessary that the epidermis be first removed or penetrated. Thus in former times it often invaded blistered surfaces, leech-bites and venesection wounds. Its frequent occurrence on the skin of the upper lip from the excoriating effect of the acrid discharge from the nostrils in nasal diphtheria has been referred to. Diphtheria having once gained a foothold on an abraded surface, spreads over the contiguous sound skin, making its way along the corion and displacing the epidermis by a process of destructive inflammation. It usually extends downward.

Diphtheria also invades the surface of wounds where no true skin remains. This is especially liable to occur in hospitals in the presence of similar conditions to those which produce hospital gangrene, with which it is often complicated. Diphtheria of wounds is characterized by the formation upon them of a whitish, grayish or greenish pellicle of varying thickness. The purulent discharge is dried up and is replaced by an acrid, ichorous fluid. The edges of the wound are thickened and œdematous, and sometimes surrounded by an erysipelatous inflammation. The affection may be superficial or deep, with a tendency to become phagedenic or gangrenous. Septic absorption is liable to occur in this as in other forms of the disease.

ALBUMINURIA AND NEPHRITIS.

If the urine of patients suffering with diphtheria be examined daily it will, in about half of all cases, be found at some time in the course of the affection to contain albumin.

According to M. Sanné,[1] out of 410 cases in which albumin was sought it was found in 224. According to Dr. J. Lewis Smith,[2] of sixty-two cases examined twenty-four were attended with albuminuria, and thirty-eight were exempt.

Albuminuria makes its first appearance in rare cases of diphtheria as early as the first or second day, then with increasing frequency until the eighth or ninth, then with diminishing frequency until the eleventh or twelfth, and in rare cases subsequently to that period. It begins, therefore, in the great majority of cases during the period at which there is the greatest intensity of the constitutional disease. In view of this circumstance it cannot be doubted that toxæmia is its principal cause in most serious cases. This conclusion is confirmed by the fact, established by many careful observers, that it is usually in those cases of diphtheria in which other evidences of constitutional poisoning are most marked that albuminuria in its more serious forms is seen.

It is, however, important to remember that there are also various other known and unknown causes of albuminuria which may be present in diphtheria, and which may be wholly or partially responsible for its occurrence, especially in its slighter manifestations. Albuminuria occurs not only in the course of infectious diseases but also in connection with various other febrile and catarrhal affections, including non-diphtheritic anginas. It occurs not infrequently in persons apparently in perfect health.[3] Among its leading causes is exposure to cold, a circumstance which often precedes an attack of diphtheria.

It is evident, therefore, that the idea, advanced by some authors, that the presence or absence of albuminuria may be a diagnostic criterion between diphtheritic and pseudo-diphtheritic affections is erroneous. It is equally evident that the argument which has often been urged, that because albuminuria sometimes appears at an early stage of diphtheria, therefore the disease is a primarily constitutional one, is based on a misconception of the facts.

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[1] Op. cit. p. 129.

[2] "Diseases of Children," 1886, p. 312.

[3] Flint, "Practice of Medicine," 1881, p. 869.

In a considerable proportion of cases in which albuminuria is due to extrinsic causes, or even to a slight degree of diphtheritic poisoning, it is small in amount, transient, accompanied with few or no renal casts and with no symptoms of uræmic poisoning, and is of no serious prognostic significance.

But many cases remain which result from the constitutional infection, are in direct proportion to the degree of that infection, are accompanied with more or less profound uræmia, and both from the mischief they indicate and the additional mischief they cause are of grave significance.

The urine presents various appearances; it is usually nearly normal in color and transparency, but frequently becomes cloudy on cooling from the precipitation of urates. It is often rather scanty and of increased specific gravity, especially in the earlier stage. In rare cases it is dark-colored or smoky from the presence of blood. The amount of albumin varies, but in severe cases it is usually in considerable quantity. In such cases there are also present granular, epithelial and hyaline casts.

Of 233 cases of diphtheria with albuminuria, according to M. Sanné, 142 died, and 91 recovered; but of 160 cases without albuminuria, 97 recovered and 63 died. Of 22 cases without albuminuria, according to Cadet de Gassicourt,[1] 12 recovered and 10 died. In 29 cases in which there was only a trace of albumin, 12 recovered and 17 died. In 19 cases in which the amount of albumin was considerable, 8 recovered and 11 died. In 16 cases in which the amount of albumin was very large, 3 recovered and 13 died.

While these figures roughly confirm the views expressed above as to the unfavorable significance of albuminuria, yet they give no precise information on that point, since they make no distinction between deaths from laryngeal asphyxia and from the effects of constitutional poisoning. Much more instructive are the following figures, given by Dr. J. Lewis Smith:[1] Of 18 cases of diphtheria without membranous laryngitis and with albuminuria, 13 died and 5 recovered; while of 31 such cases without albuminuria, 4 died and 27 recovered. "In nearly all the specimens which contained albumin—all but three or four—casts, usually granular, but now and then hyaline, and sometimes both kinds in the same specimens, were observed. In those cases of albuminuria which recovered, there were comparatively few casts or none."

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[1] Rev. Mens. des Mal. de l'Enf., November, 1884.

The assertion of Trousseau that albuminuria in diphtheria "has only a limited significance in relation to prognosis and treatment," can therefore be accepted only with important qualifications.

The duration of albuminuria in diphtheria varies from one or two days to one or two weeks, or in rare cases a longer period. It very rarely becomes chronic. It is sometimes remarkably variable or intermittent. I have in some instances seen its variations closely correspond to those of the local disease, the albumin repeatedly diminishing or disappearing with the cessation of nasal discharges or the exfoliation of membranes, and again becoming abundant on the occurrence of relapses.

Albuminuria in diphtheria is in only a very small proportion of cases attended with any marked degree of œdema. Trousseau estimates this proportion in his own experience at one case in twenty. It is especially liable to occur in those cases in which blood corpuscles are present in the urine.

Certain differences between the albuminuria of diphtheria and that of scarlatina are noteworthy. The former usually begins during the active continuance of the disease and before its tenth day, the latter at a later period and as a sequela. The former is rarely accompanied with œdema; it is a frequent attendant of the latter. The former in a smaller proportion of cases denotes important disease of the kidneys, but when this occurs it is of more serious prognostic import. The former very rarely becomes chronic; the latter not very infrequently does so.

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[1] Loc. cit.

THE LUNGS.

The pulmonary conditions which are liable to occur in connection with laryngeal, tracheal and bronchial diphtheria have already been referred to. Their symptoms are the same as when they result from other causes, but their physical signs are often so obscured by the dyspnœa caused by the laryngeal stenosis that their diagnosis is difficult or impossible. The occurrence of an increase of febrile symptoms, with excessive rapidity of respiration and with or without cough in the course of diphtheritic croup, either before or after tracheotomy or intubation, should suggest the probability of an inflammatory pulmonary complication having occurred and lead to a careful examination of the chest. Broncho-pneumonia usually results from the impeded respiration caused by laryngeal stenosis or from the extension downward of fibrinous or catarrhal bronchitis. It is maintained by some and denied by others that pneumonia may be caused by the drawing of blood into the lungs during tracheotomy.

Bronchitis, broncho-pneumonia, lobar pneumonia, pulmonary congestion, pulmonary œdema and pleurisy may occur in non-laryngeal diphtheria attended with septic poisoning, as in other adynamic toxæmic diseases.

THE HEART.

The symptoms resulting from the functional disturbances or organic lesions of the heart in diphtheria, have been referred to in describing the various stages and forms of the disease. These symptoms may be due (1) to cardiac paralysis; (2) myocardial degeneration and consequent weakening and dilatation of the heart-walls; (3) endocarditis with fibrinous deposits upon the valves of the heart; (4) gradual exhaustion of the vital forces; (5) the formation of thrombi in the cavities of the heart (ante-mortem heart-clot). Frequently several of these causes act simultaneously, especially in the later stage of fatal cases.

The occurrence of organic lesions may be recognized by the usual physical signs of these conditions. The symptoms of heart-failure may be gradual and progressive or sudden and unexpected, and may appear early in the disease or at a late period and after apparent convalescence.

ERUPTIONS.

Eruptions have been described by various observers of diphtheria as having occurred in a portion of the cases of the disease in some epidemics. The predominant form has resembled the exanthem of scarlatina, but other forms have been similar to that of measles or that of roseola or to urticaria, and still another has been vesicular. These eruptions are attended with no special symptoms and are not followed by desquamation. They have not usually been observed to have any definite significance as to the gravity of the disease or its prognosis. In the observation of many hundreds of cases of diphtheria I have never seen an accompanying eruption that was not evidently a purely accidental complication. In the observations of M. Sanné[1] one case in fifty was attended with an eruption. The supposition of some writers, that these eruptions hold the same relation to diphtheria that those occurring in typhus or typhoid fever hold to those diseases, seems to be negatived by the extreme rarity of their occurrence and by their lack of uniformity in type. It is reasonable to suppose that some of the recorded cases may have been in reality cases of scarlatina, in which the eruption was so slight and so transient and the accompanying symptoms so incomplete that the real nature of the affection was not recognized. The majority are doubtless merely cases of erythema "simplex" or "fugax," occasioned by the fever under certain individual or local or epidemic conditions.

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[1] Op. cit. p. 138.

Purpura hæmorrhagica has been already referred to as not infrequently occurring in the course of malignant and grave forms of septic diphtheria.

CHAPTER V.

THE PRIMARY NATURE OF DIPHTHERIA.

Is diphtheria primarily a local or a constitutional disease? The importance of this question arises from the fact that its answer must be fundamental to any rational theory of treatment.

In 1876, I stated[1] that the result of my clinical observations, which had included the early stages of many cases, had been to make me a convert to the minority, who believe that the source of the constitutional disease is, in the great majority of cases at least, to be found in the local affection.

I have since been confirmed in that view by many subsequent clinical observations, and also by important corroborative facts which have been elicited in pathological and bacteriological research by investigators in this and in other countries, and which have been stated in the chapter on etiology.

I shall now present some of the clinical facts upon which this belief is based, and shall consider some of the statements and arguments which have been advanced in opposition to it.

First.—Diphtheria occurs in the great majority of cases upon the mucous membrane of the fauces, the larynx, the nasal passages and the mouth, or, in other words, the outer avenues of entrance of inspired air and of food and drink, and with the greatest relative frequency in exactly those positions where particles of matter introduced by them would most naturally be deposited, which fact suggests a probability that the disease is directly and locally caused by such contact or implantation. This probability is greatly strengthened by the fact that it occurs in sharply limited, irregular and non-symmetrical areas, which is not the case with the throat-inflammations resulting from blood-diseases, such as scarlatina and small-pox. This probability is still further strengthened by the fact that when it attacks the skin, which has a more efficient protection in its epidermis, it affects only such portions of it as have been deprived by wounds and abrasions of that protection. These circumstances taken together constitute a very strong *a priori* argument. Although they have not escaped previous notice I have never seen a satisfactory explanation of them in accordance with the opposite theory of the disease.

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[1] "Diphtheria and its Treatment, with Statistics of one hundred and seventy-nine Cases." Transactions of the New York Academy of Medicine, 1876, p. 286.

It is argued,[1] *per contra*, "If diphtheria were a local disease at first, commencing in the throat and then becoming constitutional by absorption, what organs would be more exposed to the reception of its poison than the digestive passages, which are in habitual contact with the *débris* of the false membranes swallowed with the saliva and with food, when they are not constantly bathed in an ichorous fetid liquid which proceeds from the fauces? In spite of these conditions, so favorable to the development of false membranes, their presence in the œsophagus, the stomach and the intestine is exceptional." This argument has apparently great force, for while it may readily be answered, in so far as the stomach and intestines are concerned, that the gastric juice has probably the property of destroying the infectiousness of the materials referred to, some other explanation is required for the exemption of the œsophagus, which is most directly exposed to them and is not thus defended. That explanation may be found in the protection which it receives from the especially dense epithelium which covers its mucous membrane.

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[1] Sanné, Op. cit., p. 362.

Zenker and von Ziemssen[1] remark: "The sharply defined anatomical and histological differences between the mucous membrane of this organ and the parts with which it connects at either end are usually accompanied with an equally well-defined limitation of pathological processes, particularly the inflammatory." Another and more comprehensive explanation of the exemption of the regions referred to from diphtheritic inflammation has been referred to in the chapter on etiology, in the fact that free oxygen is under ordinary conditions absent in them, and that the bacterium of diphtheria is probably aërobious—either explanation being in accordance with the theory of the local character of the disease.

Second.—The constitutional disease, as I have more fully stated in the chapter on symptoms, is, in the order of time, not antecedent to but consequent upon the local affection. Fever, rigors, or even convulsions may indeed be the first symptom to attract attention and do precede the formation of membrane, but in all cases, if the throat be examined at that stage of the disease, inflammation will be found to be present.

A common source of error on this point is that the "symptomatic" fever and nervous disturbances which are common to the onset of many inflammatory affections, including simple catarrhal anginas, are strangely confounded with the evidences of constitutional infection or blood-poisoning, which in diphtheria, as is universally agreed, consist of pallor, somnolence, weakness, etc. In most clinical descriptions of diphtheria, the last-mentioned symptoms are said to usually occur at various periods of the disease subsequent to the local inflammation and the formation of membrane.

Another cause of much error on this point is the fact that in some cases in which pseudo-membranous exudation already exists there has been no complaint of pain or soreness of the throat. The more strictly the physician observes the rule to examine the throat of every sick child, the fewer will be the cases in which he will suppose the constitutional symptoms to have preceded the local ones.

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[1] "Diseases of the Oesophagus," Ziemssen's Cyclopædia, vol. viii.

Another source of error is the fact that diphtheria often supervenes upon some other disease. A child, for instance, has taken cold, from the effects of which he is drooping and feverish for several days. Upon the catarrhal sore-throat thus produced diphtheria sets in. The previous symptoms are naturally supposed to have been those of the invasion of the latter disease, when in fact they were nothing of the kind.

Still another source of error, and a very important one, is the fact that false membrane often occurs in some concealed situation. That situation is most usually the posterior nares. I have in a number of instances found an explanation of constitutional symptoms of diphtheria which were otherwise unaccountable, by washing portions of false membrane from that locality by nasal syringing. Dr. D. Bryson Delavan has informed me that he has seen quite a number of instances of physicians or nurses who, after attendance upon cases of diphtheria, have suffered from the constitutional symptoms of the disease, although no membrane has been visible in the throat or elsewhere by ordinary modes of inspection; but on examining the posterior nares with the rhinoscopic mirror, patches of unmistakable diphtheritic membrane have been seen in that situation. In one fatal case with symptoms of diphtheritic poisoning which was reported by me,[1] the only false membrane was found post-mortem in the bronchial tubes. Such facts furnish an obvious explanation of cases which have been adduced in support of the assertion that diphtheria may occur without a *diphthera*.

To the statements which have just been made are opposed contradictory ones by writers of great excellence and authority. M. Sanné, who argues with earnestness and force in favor of the primarily constitutional nature of diphtheria,[2] says, "It is quite as common, if not more so, to find the diphtheritic poisoning evident from the outset, and it is those cases in which it is most intense which begin thus; the false membrane is then but an unimportant element." But when we turn from that statement, made in the stress of argument, to the chapters in which he describes the symptoms of the disease, we find the onset of the different forms thus delineated: "*Benign form.*—This commences by a début like one of the non-diphtheritic inflammatory anginas, provided they acquire a certain violence." The usual symptoms of the onset of this class of affections—fever, rigors, anorexia, lassitude, headache—are mentioned (page 118). "The same day or the next one the patient, if he is old enough, complains of a sore throat," etc. "Examination of the throat shows *from the outset* (d'abord) a more or less vivid redness of the pharynx." (page 182). No symptom distinctive of diphtheritic poisoning is mentioned in connection with the onset of this form.—"*Infectious form.*—The commencement is the same" (as in the previous form), "but *at the end of a few days* characteristic symptoms appear" (page 119). One of these is (page 120) that "the complexion, *at first bright*, becomes pale, livid, leaden." (The italics are mine.) The malignant form presents two varieties. "In the first" (page 122), "which may be called *forme foudroyante*, the symptomatic complex is the same as in the preceding form, and is distinguished from it only by the *rapidity with which the symptoms succeed.*" In this form the false membranes may be very extensive or very slight, but "however limited they may be the neck presents an enormous tumefaction" from glandular swelling. What description could be more suggestive of toxic absorption from a local source? The second variety, the "*insidious form*, leads in the beginning to an expectation of benignity which proves cruelly deceptive. The lesions are unimportant, but they extend from the throat *into the nose*"—a situation which M. Sanné elsewhere recognizes as especially favorable to toxic absorption. In short, while we find in the admirable general descriptions of diphtheria by this author, which may fairly be presumed to include its more usual manifestations much which is illustrative of constitutional poisoning from a local source, we search in vain for distinctive evidences of diphtheritic poisoning at the initial stage of the disease, unless, indeed, the fever and the concomitant nervous disturbances which attend the primary inflammation are to be so regarded.

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[1] New York Medical Record, April 16, 1887.

[2] Op. cit., p. 363.

This view is not without advocates. Since the fever, however, behaves in diphtheria precisely as it does in various simple catarrhal anginas—that is to say, as a general rule begins and ends with the inflammation, and is in direct proportion to it—it is most natural to suppose that it is, as in them, simply the attendant and the result of the inflammation. Exceptionally, it is true, it apparently precedes the latter by a little, or is disproportionately high, but this is likewise true in ordinary catarrhal anginas, and when it is the case we look for the explanation either in some constitutional peculiarity of the patient, or in some peculiarity of the inflammation which is not evident, or in some undiscovered complicating inflammation or in some pre-existing and complicating constitutional poisoning (malarial, septic, rheumatic, etc.), which explanations are equally available in diphtheria.

Third.—The gravity of the general disease varies directly, as a general rule, in proportion to the extent and more particularly the depth of the local affection. While this proposition is substantially sustained by the testimony of most observers of various pathological views, it is maintained, *per contra*, by some excellent authorities that the correspondence referred to is not constant, that a grave constitutional disease may accompany a very slight local affection, and that death has resulted from the primary poison of diphtheria in cases in which but little membrane or even no membrane has existed.

It is answered that such cases are admittedly so rare as to be exceptional, and that there is great liability to error respecting them. To the sources of such possible error already referred to in defective observation and in the occurrence of diphtheritic membrane in concealed situations, the following may be added, all of which have been illustrated in my own experience: An apparently insignificant membranous patch which penetrates deeply may result in profound toxæmia, while an extensive but superficial one may cause scarcely any. A trivial membranous deposit in situations favorable to absorption (as for instance the nares) may have far greater constitutional results than apparently formidable ones in different anatomical relations (as the convexity of enlarged tonsils). Again, it is well known that epidemics of diphtheria and of scarlatina are frequently associated, and that this association has been a fruitful source of confusion. How naturally under such circumstances might a death from malignant scarlatina without eruption be erroneously attributed to diphtheria! Finally, it must be admitted that in some cases of diphtheria the amount of false membrane is disproportionately slight to the septic intoxication; but it does not necessarily follow that the latter is the primary fact. It is more reasonable and more in accordance with many analogies in surgical and puerperal sepsis to suppose that the progress of the disease from local to general is in these cases either from some special condition or tendency pre-existing in the patient, or some extraordinary virulence in the contagium, or perhaps from both circumstances concurring, more rapid than in ordinary ones, and that it is complicated by the early penetration into the system of septic microbes.

Fourth.—The employment of proper local antiseptic treatment does in many cases promptly mitigate or quite dispel constitutional symptoms previously existing, or, if early employed, prevent, either wholly or in some measure, their occurrence, and its failures to accomplish these objects occur in exactly those cases in which from the nature of things it cannot be or in which it is not efficiently employed. The proof of these assertions will be presented in the chapter on treatment, to which the reader is referred.

While the foremost place in the treatment of diphtheria is conceded to topical measures by many authorities who hold to the opposite pathological view of the disease, it is asserted by some as an argument in favor of that view (1) that local treatment does not cut short the disease, and (2) that it does not in severe cases prevent the occurrence of constitutional symptoms. Even if the first assertion be true, which question will be elsewhere considered, the argument is without force, since the same is admittedly true in the case of gonorrhœa and some other local affections, which evidently penetrate the living tissues too deeply to be eradicable by disinfectants which act only or mainly on their surface. In reference to the second assertion it may be said that the limitations to the efficacy of local antiseptic treatment in diphtheria, being such as is stated above, are in reality, equally with its successes, illustrative and confirmatory of the theory of the primarily local nature of the disease.

The assertion[1] that diphtheria and syphilis are analogous is misleading, since the analogy is at most only a partial one; for even admitting that both diseases become constitutional simultaneously with the occurrence of the primary lesion (which if it be true in diphtheria must in many cases be so in only a slight and unimportant degree), yet they differ in these two important respects: There is not in syphilis any usual proportion between the gravity of the primary and the secondary affections, and the secondary disease goes on independently of the primary affection and uninfluenced by treatment applied to it.

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[1] Sanné, loc. cit.

CHAPTER VI.

SECONDARY DIPHTHERIA.

SECONDARY DIPHTHERIA is that which attacks a person who is already suffering from another disease of which the diphtheria is in some degree the result.

Strictly speaking, a large proportion of all cases of diphtheria are secondary rather than primary, since, as has already been seen, various catarrhal affections of the mucous membranes prepare a favorable soil for the insemination of diphtheria. The term secondary, however, is more usually applied to that diphtheria which supervenes upon other specific diseases.

Secondary diphtheria is usually subject to the two following laws: (1) It manifests itself only after the primary disease has run its active course, or, at least, after its intensity has begun to abate. (2) It occurs on those mucous membranes which have been especially affected, and thus prepared for its invasion, by the primary disease.

Secondary diphtheria, or an affection resembling diphtheria, undoubtedly occurs with the greatest frequency in connection with scarlatina. It is a mooted question whether the pseudo-membranous formation which so frequently appears in the course of this disease is a true and distinct diphtheria, or is merely a product of the scarlatinal inflammation. I believe that both views are in part correct, or, in other words, that there is a very common diphtheroid affection which is merely a part of scarlatinal angina, and also that true diphtheria very often supervenes upon scarlatina.

It is common to see from the second to the fifth day of scarlatina the previously bright red mucous membrane of the throat become coated over with a white pellicle which is in appearance distinctive. It is thin, filmy, uniform, only slightly elevated above the surrounding mucous membrane, is not in well-defined sharply limited patches as in the case of true diphtheritic membrane, but its borders shade off from the unaffected surface by an almost imperceptible gradation. It does not lie loosely upon the surface of the mucous membrane, nor can it be readily detached from it, but is closely adherent to it, and presents to the eye the appearance of being a transformation in its most superficial epithelial layers, which indeed it probably is. It is often quite extensive, covering one or both tonsils, one or both faucial arches, the anterior surface of the soft palate, the uvula, and in some cases the posterior wall of the pharynx. It is accompanied with a more or less abundant thin or glairy muco-purulent secretion. It usually persists through the active stage of the disease and then melts away by desquamation. I have seen this form of affection in many cases. It has never produced any of the systemic conditions which are peculiar to diphtheria, nor has it been followed by paralysis. From this circumstance, from its uniform distinctiveness of character, and from the early stage of the disease at which it appears, I regard it as exclusively a result of the scarlatinal inflammation.

There is a very different affection which usually appears at a later stage of the disease—from its sixth to its tenth day or even later—when its intensity has begun to abate. This commonly commences in the pharynx with the usual symptoms and appearances of faucial diphtheria, including well-defined patches of true diphtheritic membrane of varying thickness, fœtor, adenitis, septicæmia, etc. It has a great tendency to extend over the regions which have been most affected by the scarlatinal inflammation, especially the nasal passages, the Eustachian tubes and the middle ear. It has even in some cases invaded the eye by way of the lachrymal duct.

I have seen the first-described affection very common in some epidemics of scarlatina at times when diphtheria was not at all prevalent, and, on the other hand, have seen the one last referred to a very frequent and formidable complication or sequel to scarlatina at times when diphtheria was epidemic.

True diphtheria may supervene upon the diphtheroid form of scarlatina, the whole aspect of the case being thereby speedily changed.

It will be seen that unless the distinction which has now in its clinical aspects been pointed out be borne in mind, comparative anatomical observations on the false membranes of scarlatina and of diphtheria can have little value, as all forms of diphtheritic metamorphosis of tissues are seen in connection with scarlatina. Yet Heubner would seem to have had in view the diphtheroid pseudo-membrane which I first described when he said,[1] "True tissue-diphtheria is beautifully illustrated and developed in scarlatina, and differs from it only in this respect, that in the latter only the epithelium and superficial capillaries are affected, while in the former both mucous and sub-mucous layers, including the blood-vessels, are implicated in the process of coagulation-necrosis."

It cannot be denied that true diphtheria does in exceptional cases accompany scarlatina at a very early stage, or may even be the prior affection, but in such cases the diphtheria can be regarded only as an accidental complication of the scarlatina. In the records of many epidemics, especially by the earlier writers, as we have seen in the chapter on history, the features of diphtheria and of scarlatina are mingled together in inextricable confusion, each having resulted from the contagion of the other, and not only pharyngeal and nasal but laryngeal diphtheria having often been early concomitants of scarlatina. Such facts can only be explained by the supposition that unusually intense epidemics of each disease were concurrent.

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[1] Die Experimentelle Diphtherie.

Diphtheria in following measles conforms to the two general rules above stated, in appearing as the eruption and acute symptoms of the prior disease are abating (namely after the fifth or sixth day of the eruption) and in being localized where its principal lesions have occurred. Hence it has been found to furnish a particularly large proportion of cases of the laryngeal and tracheal affection. For this reason the complication is an especially formidable one, the mortality, according to some statistics, being eighty per cent. (Sanné.)

Diphtheria has also been a very frequent complication in some epidemics of small-pox, and has shown an especial tendency to affect the larynx and trachea.[1]

In typhoid fever, diphtheria rarely occurs before the end of the second week. It frequently affects the larynx, but owing to the obtunding of the sensibilities by the disease, and the fact that many of the patients are adults, it often fails to be recognized during life.

In accordance with the second law above referred to, secondary diphtheria is sometimes located in regions which are very rarely visited by primary diphtheria. Thus diphtheria of the œsophagus is usually consequent upon typhoid fever, cholera, measles, scarlatina, small-pox, pulmonary tuberculosis and pyæmia, and that of the gastric mucous membrane upon scarlatina and small-pox. (Ziegler.)

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[1] Rühle, Die Kehlkopf. Krankheiten, Berlin, 1861, p. 247.

CHAPTER VII.

DIPHTHERITIC PARALYSIS.

ONE of the most striking peculiarities of diphtheria is the frequency with which it is followed by paralysis. The proportion of cases in which this sequence has occurred has varied, according to different observers, from 1.15 to 66 per cent. Of 1382 cases observed by Sanné, eleven per cent. were followed by paralysis. In view of the liability of very mild cases of paralysis to be unrecognized, the estimate of Gowers[1] of twenty-five per cent. of all cases is perhaps not excessive.

Diphtheritic paralysis is usually a sequela, for, while it occasionally appears early in the course of the primary disease, yet in by far the greater number of cases it is first manifested in the second or third week, and has occurred as late as the fortieth day after the disappearance of the local symptoms. It follows the mildest cases as well as the most severe ones. According to the statistics of Landouzy[2] the tendency to its occurrence is very slight in infants and increases with age. It has one usual starting-point, the soft palate, to which in a large proportion of cases it is limited. When it invades other parts successively there is a certain order of progression which, as a rule (though subject to many exceptions), it observes. It is, in the great majority of cases, a paresis rather than a complete paralysis. It is, as a rule, of comparatively brief duration. Its termination, with relatively few exceptions, is in complete recovery.

Paralysis of the soft palate and pharynx first manifests itself by modifications in the voice. Articulation, especially of the palatal consonants and vowels, is difficult or impossible. Speech may present all grades of imperfection, from a slight nasal twang to complete unintelligibility. Deglutition is also interfered with in various degrees. In the least degree there is experienced a slight slowness or clumsiness in the act of swallowing. In a greater degree, liquids are regurgitated through the nose. Solids are swallowed more easily, but even they in bad cases give much trouble, missing the œsophagus to enter the larynx or to remain in the naso-pharyngeal cavity. Small portions usually cause more inconvenience than larger quantities. This interference with swallowing in some cases makes the taking of necessary nourishment a matter of extreme difficulty. Expectoration, or the expulsion of mucus from the throat and nasal passages, is in like manner rendered difficult or impossible.

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[1] "Diseases of the Nervous System," p. 1221.

[2] "Des Paralysies dans les maladies aigues," Paris, 1880.

If the mouth be opened the soft palate is seen to hang relaxed and motionless. When the paralysis is unilateral it is drawn toward the healthy side. It has partially or wholly lost its sensibility and does not respond to tickling or irritation by the usual reflex movements. The muscles of the tongue, lips, and face are sometimes affected.

Disturbances of vision are of frequent occurrence. They usually appear soon after the commencement of the palatal paralysis, but in rare cases simultaneously with it or even before it. The most common form is asthenopia. There is difficulty in reading fine print or distinguishing other small objects. Efforts to do so are quickly followed by fatigue and blurring or flashes of light before the eyes. The vision of distant objects is not usually impaired. These symptoms are due, according to the researches of Donders,[1] mainly to defective accommodation from paresis of the ciliary muscles. In some cases there are diplopia, vertigo and strabismus of one or both eyes, from the involvement of the oculo-motor muscles, and more rarely ptosis, from implication of the levator palpebræ superioris.

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[1] British Med. Jour., May 12th, 1877, p. 505.

Next in order of occurrence are paralyses of the muscles of the extremities, those of the lower extremities being usually the first, and sometimes the only ones, to be affected. The affection commonly begins with disturbances of sensation, such as feelings of coldness, numbness, tingling or sharp pains. Various degrees of feebleness in some or all of the muscles concerned in locomotion are next experienced. The ground often feels soft and yielding from impairment of the muscular sense. Cutaneous sensibility is sometimes abolished, especially in the soles of the feet. Anæsthesia is sometimes accompanied with analgesia, which may be general in the extremity affected or confined to limited areas. Sometimes the symptoms are those of ataxia. The movements are incöordinate and the patient cannot walk with his eyes closed. The affection of the muscles rarely exceeds a greater or less degree of paresis, and is often, as in other situations, limited to particular muscles or groups of muscles, but in rare cases absolute paralysis of the lower extremities ensues. In proportion to the degree and duration of the paralysis there are flabbiness and a tendency to atrophy of the muscles.

A similar order of symptoms may occur in the upper extremities. Tactile sense in the fingers is diminished or lost. The affection is more usually partial and limited to certain muscles, causing tremor or choreic movements, and feebleness, clumsiness and uncertainty in the use of the hands and arms. In rare cases the paralysis here also becomes complete.

Diphtheritic paralysis in the extremities is most usually symmetrical, though often somewhat unequal in the two sides. Its absolute limitation to one side is very rare, though not altogether unknown.

Diphtheritic paralysis of the muscles of the larynx seldom occurs alone or in connection with that of the pharynx merely, but usually appears only in the course of more general paralysis. It may be limited to one muscle or may be general. Its presence may be recognized by modifications in the quality of the voice, varying, according to the extent and degree of the affection, from slight roughness or loss of resonance to absolute aphonia. Tranquil respiration is not seriously interfered with, but coughing, forcible expiration, and "holding the breath" are rendered difficult. Loss of sensibility in the laryngeal mucous membrane sometimes accompanies the motor paralysis. From this cause portions of food have entered the larynx unperceived by the patient and have caused death by suffocation. This accident may also result from sensory and muscular paralysis of the epiglottis.

On laryngoscopic examination it is found that one or both vocal cords have lost in part or wholly their motility. When only one muscle is affected the position of the vocal cord is fixed by the antagonistic action of the non-paralyzed muscles. When the paralysis of the laryngeal muscles is general, the vocal cords are motionless midway between the positions of phonation and of respiration, as in the cadaver.

Paralysis of the muscles of the neck and trunk is usually one of the latest developments in general diphtheritic paralysis. When the former are seriously affected the patient is unable to raise or hold up or turn the head, which droops helplessly. When the latter are paralyzed he is similarly deprived of the power to hold the body upright, or even to turn in bed. Implication of the intercostal muscles causes serious embarrassment to respiration. When the diaphragm is also involved, the shallowness and difficulty of breathing are greatly increased, and in proportion to the degree of the paralysis there are cyanosis and liability to death from asphyxia.

The heart is also affected by diphtheritic paralysis, and to this fact is due by far the greatest number of its fatal results. The time at which this affection occurs varies widely. It sometimes takes place in the second or third week of the primary disease, or, in rare cases, even earlier, and, on the other hand, is not infrequent in advanced convalescence, and is usual in the course of general diphtheritic paralysis.

Its severity and fatality are, as a general (though not invariable) rule, greatest when it occurs early. Even then it has usually been preceded by palatal or pharyngeal paralysis, though it is not impossible that the heart should be the part first affected. Its onset in this form is usually sudden. It is often attended with a rigor or a sensation of chilliness. It is frequently preceded or accompanied with symptoms of gastric disturbance and failure of digestion, such as nausea, anorexia, etc. There is a sudden accession of dyspnœa and precordial oppression. The countenance expresses distress and alarm, and its hue is pale or cyanotic. The surface, especially of the extremities, is cold. The pulse is weak, fluttering, intermittent and variable, the heart-sounds muffled, confused and irregular. Death may ensue quickly, or only after a number of hours, or the attack may be partially recovered from only to return again, or (too rarely) the recovery may be complete and permanent. Cadet de Gassicourt records only one recovery in fifteen such cases.

As it occurs at a later period, diphtheritic paralysis of the heart, like that of other organs, varies from a slight and transient paresis to a suddenly fatal cessation of function. In the whole number of cases the fatal results are doubtless fewer than the recoveries.

During the continuance of cardiac paralysis there is great liability to an aggravation of the condition by exertion, even the slightest effort having in many cases been followed by a fatal result and in others by alarming but transient symptoms of heart-failure. An interesting case of a practicing physician of this city, as related by himself, is published by Dr. A. D. Rockwell.[1] In this case "cardiac difficulty," paresis of soft palate, pharynx and larynx, of ciliary muscles, of upper extremities, of lower extremities and of bowels, appeared in the order mentioned, beginning about the third week after the disappearance of the diphtheritic patches and ceasing in the sixteenth week, except that slight cardiac feebleness remained for fifteen months. The cardiac difficulty mentioned was indicated by a very feeble, soft, slow pulse averaging sixty per minute. "On one occasion, immediately following special exertion, the pulse quickly rose to 160 and as quickly fell to 32 per minute, resulting in an attack of angina pectoris, which persisted for nearly three hours. This sudden fluctuation of the pulse was most alarming, and caused apprehension of immediate dissolution." It is also stated that the symptoms, not only of the cardiac but of the other paralysis, "were invariably increased by the slightest exercise."

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[1] "Medical and Surgical Electricity," p. 629.

The walls of the intestines and of the bladder and also their sphincters are occasionally affected with diphtheritic paralysis, producing in the former case retention of their contents, and in the latter involuntary fecal movements or incontinence of urine. Anaphrodisia and impotence are not infrequent sequelæ. Paralyses of the special senses, such as temporary amaurosis, deafness, and impairment in various degrees of taste and smell, have been observed. Anæsthesias and dyæsthesias have also occurred without accompanying motor paralysis.

While the order of occurrence of the various localizations of diphtheritic paralysis which has now been indicated is a usual one, it is far from being invariable, and they may take place successively in any order whatever, or any number of them may be present at the same time. Thus, in the case of a physician, reported by himself,[1] the order of events was as follows: Pains in axilla, arms and hands; motor paralysis of lower extremities; loss of sensation in limbs and trunk; sensory and motor paralysis in upper extremities; loss of sensation in mouth, tongue and portions of face; paralysis of soft palate; dimness of vision; increase of motor and sensory paralysis in arms and hands; paralysis of bladder; loss of power of erection; paralysis of interosseous muscles.

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[1] Dr. Reed, Boston Med. and Surg. Journal, July 13th, 1876.

The duration of diphtheritic paralysis is generally in proportion to its severity. I have seen a paresis of the soft palate entirely disappear within eight days from its commencement, and from two to six weeks is a frequent duration. More general cases may last for as many months, and in rare instances some of the symptoms persist for years.

The small proportion of cases which terminate fatally do so from inanition caused by difficulty in swallowing, from the effects of the entrance of foreign bodies into the air-passages in pharyngeal and laryngeal paralysis, and from pulmonary affections produced or aggravated by that paralysis, from asphyxia in paralysis of the respiratory muscles and from heart-failure in cardiac paralysis.

The reaction to electricity in many cases of diphtheritic paralysis is not perceptibly altered. In severe ones faradomuscular contractility is usually diminished, while galvanomuscular contractility continues normal or is exaggerated. In grave cases of long duration, in which the muscles are atrophied, their contractility under the galvanic current is diminished or lost. Thus the reactions to electricity in diphtheritic paralysis are generally those of peripheral nerve degeneration, as has been pointed out by Ziemssen[1] and many subsequent writers.

The onset of diphtheritic paralysis is usually, though not invariably, accompanied by the loss of the knee-jerk. The remarkable fact was discovered by Bernhardt[2] that the knee-jerk is abolished, not only in actual diphtheritic paralysis, but in a large proportion of all cases of convalescence from diphtheria that are unattended by recognizable paralysis. In twenty-one such cases examined by him the knee-jerk continued on both sides in seven, but was absent on one side in one, and on both sides in thirteen, the loss occurring in two-thirds of his cases. This observation has since been abundantly confirmed. The abolition of the knee-jerk usually occurs in the latter part of the first month after the onset of the primary disease, or in the course of the second month, and continues for four or five months. Its disappearance is frequently preceded by its temporary exaggeration. Its return is at first unilateral and is gradual, there being alternations of its occurrence and its non-occurrence. The knee-jerk may be present in post-diphtheritic ataxia, and may be absent when there is no ataxia.

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[1] Berl. Klin. Wochenschrift, 1866, Nos. 43 and 44.

[2] Virchow's Archiv., 1885, Bd. 99, p. 393.

Loss of knee-jerk also occurs at an early stage of some cases of diphtheria. Dr. R. L. McDonnell[1] states that in eighteen cases of diphtheria in the Montreal General Hospital, knee-jerk was absent at the time of admission in 10, and present in 8.

Albuminuria is a frequent, but not a constant, accompaniment in grave cases of diphtheritic paralysis. Thus of sixteen fatal cases described by Abercrombie, albuminuria occurred in one fourth.

The anatomical changes which have been observed in fatal cases of diphtheritic paralysis have been elsewhere described (page 65). They consist in inflammatory and atrophic changes in the gray matter of the anterior horns of the spinal cord; inflammatory or degenerative lesions of peripheral nerves; changes in the vascular system and its contents, and atrophic changes in muscles.

The changes in the nerves are in the greater number of cases primarily and mainly in the nerve-elements themselves rather than in the investing or interstitial tissues. They are characteristic of "parenchymatous neuritis," a degenerative condition which may begin at any point in the course of a nerve, or may be consecutive to lesions in the spinal nerve-cells. It extends downward in the course of the nerve from its point of commencement, but not upward.

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[1] Medical News, October 15, 1887, p. 448.

In other cases inflammatory changes in the interstitial elements of the nerves predominate. Interstitial neuritis, unlike the parenchymatous, may extend upward in the nerve. Its occurrence in the palatine nerves may be due to the proximity of their terminal filaments to the seat of the primary diphtheritic inflammation and their consequent exposure to the direct action of the poison there evolved. That this is the case in some of the instances in which the diphtheritic inflammation in the soft palate is intense and the paralysis in that situation occurs early is not improbable. That the usual commencement of diphtheritic paralysis in the soft palate cannot in all cases be thus explained is shown by the facts of pathological anatomy above referred to, and also by the clinical facts that paralysis often occurs when the pharyngeal inflamation has been extremely slight and fails to occur when it has been intense, and that palatal paralysis has appeared in some cases in which there has been no sore throat, the diphtheritic inflammation having occurred on wounds, etc. in remote situations, and that paralysis following pharyngeal diphtheria sometimes commences in remote parts of the body. Yet such cases must be regarded as exceptional, the general fact being that diphtheritic paralysis usually commences in what may be called regional proximity to the site of the original disease. Trousseau, after referring to several of the cases just alluded to, adds, "Generally, however, where the paralysis is consecutive to cutaneous diphtheria it commences in the extremities;" and many recorded cases support this statement.

It must be remembered that the anatomical lesions above referred to, occurred in fatal cases. That in ordinary cases they are far less grave is evident from the clinical fact that recovery in them is usually speedy and almost always complete. Yet it is reasonable to suppose that the difference is rather in degree than in kind, the disturbance in the nutrition of the nerves affected varying through all gradations from that which is so slight as to be manifested only in a transient and scarcely perceptible impairment of function to that which is destructive and fatal. The generally accepted view of the pathology of the most usual forms of diphtheritic paralysis is stated by Dr. T. Buzzard[1] as follows: "I do not think that with the clinical evidence before us we are justified in saying that diphtheritic paralysis in its ordinary form, passing to complete recovery, is dependent upon an affection of the spinal cord. It is, in my opinion, more reasonable to conclude that in this disease we have usually to do with peripheral neuritis of very varying severity, which in the mildest cases is probably represented by a mere transitory hyperæmia with effusion in the interstitial element."

The precise manner in which diphtheria causes diphtheritic paralysis has not yet been demonstrated. It has been held by many that the disturbance of nutrition in the nervous system which underlies the paralysis is wholly or mainly due to the anæmia which is a striking characteristic of convalescence from diphtheria. This view is negatived by the fact that paralysis often occurs in cases in which anæmia is slightest and fails to occur in those in which it is most marked, and moreover that in other conditions in which anæmia is equally profound the symptoms which are peculiar to diphtheritic paralysis are unknown.

A consideration of the pathological and clinical facts which have now been referred to, in connection with what has elsewhere been stated in reference to the pathology of diphtheria, can leave no reasonable doubt that diphtheritic paralysis is due to the action upon the nervous system of a poison, the presence of which in the organism is in some way the result of diphtheria. It is also highly probable that that poison belongs to the class of ptomaïnes. But the exact nature of that poison and of its action upon the nervous system is involved in no little obscurity. It has been assumed by some that it is the diphtheritic virus itself; but opposed to that view are the facts that paralysis follows only a small proportion of all cases of diphtheria, and that the probability of its occurrence and its severity when it occurs bear no relation whatever to the character of the primary disease, and also that in some cases it commences weeks after the cessation of the primary disease, and only reaches its height several months later. The loss of the knee-jerk is also without known definite relation to the character of the disease and to the subsequent occurrence of paralysis. Many circumstances favor the hypothesis that the cause of diphtheritic paralysis is a distinct nerve-poison concomitant to or resultant from the diphtheritic virus, and generated in the system along with it or subsequently during the period of convalescence in some cases, but not in others. In support of this theory the following remarkable facts are cited by Gowers[1] from Boissarie: "In a certain district of Paris there occurred a series of cases of severe diphtheria, and at the same time a series of cases of paralysis of the palate, eyes, limbs, heart, etc. perfectly like that which occurs after diphtheria, and accompanied by albuminuria. The remarkable fact is that in these cases of primary palsy there was no history of preceding sore-throat, and in several of the cases distinct diphtheria followed the paralysis, which lessened during the throat-affection. Some of the cases of primary palsy seemed to arise distinctly by infection."

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[1] Lancet, Dec. 19, 1885, p. 1128.

Dr. W. H. Thomson says:[2] "Our knowledge of the action of the micro-organisms is sufficiently advanced now for us to know that some of them evidently cause disease by generating definite poisons or ptomaïnes, which are absorbable into the blood, and then act there just as other poisons act, some of them as even arsenic does, causing multiple neuritis of a disseminated and yet selective kind. . . . . . It becomes quite conceivable to infer that the working of the diphtheritic organism may prepare, in certain cases, the way for some subsequent process in the body by another organism, when the conditions for its growth have been fulfilled by the antecedent presence of the diphtheritic agent, and that it is during this subsequent process that the poison which works such mischief on the nervous mechanism is produced."

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[1] Op. cit., p. 1233.

[2] Loc. cit.

The probability that this poison causes paralysis in most cases by producing trophic disturbances of very various degree in the peripheral nerves has already been referred to. That in some cases it has a direct and powerful paralyzant effect upon the nerves by arresting their function without producing any appreciable structural lesion has been shown in various autopsies. That this may probably be its action in cases of early and sudden heart-failure, and also in other forms of early and transient diphtheritic paralysis has recently been shown with much force of reasoning by Dr. J. Lewis Smith,[1] the principal arguments adduced being the following: Ptomaïnes spring into existence suddenly and unexpectedly under favoring conditions. Cases occur in which carefully conducted microscopic examinations reveal an apparently normal state of the nerves supplying the paralyzed part, and of that part of the cerebro-spinal axis from which the nerves arise, and also, in cases of heart-failure, of the heart itself. Palatal paralysis sometimes occurs as early as the second or third day of diphtheria, and loss of the tendon-reflex as early as the first day; and it seems improbable that a peripheral neuritis or anatomical changes in the cerebro-spinal axis, such as to cause paralysis, should occur at so early a date. In its commencement diphtheritic paralysis often suddenly shifts from one group of muscles to another, or there is a sudden recovery from it on one day, and a recurrence of it on the next; which would seem impossible if it resulted from degenerative nerve-changes, either central or peripheral. The incomplete or partial character of the degenerative changes in peripheral nerves which have been observed by some microscopists would hardly account for the complete paralysis which often exists, for instance, in the velum palati.

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[1] "Sudden Heart-Failure in Diphtheria; its Pathology and Treatment," Medical News, Nov. 10, 1888, p. 536.

The various facts which have now been referred to seem to warrant the following general conclusions: 1. "It may be positively asserted that diphtheritic paralysis does not in every case depend on one and the same cause" (Jacobi). 2. The early forms of the affection are probably due mainly to a direct inhibitory effect upon nervous function either of the diphtheritic poison or of some other poison which is often, but not necessarily, associated with it. 3. The later forms of the affection result from pathological changes in the nervous system, the most usual form of which is parenchymatous or degenerative peripheral neuritis—these changes being initiated by the diphtheritic poison or poisons and favored by the impoverished condition of the blood.

CHAPTER VIII.

DIAGNOSIS.

THE recognition of grave forms of diphtheria, when fully developed, is usually easy; but then the recognition is often too late. It is the earlier stages and milder forms of the disease which need to be intelligently discriminated from certain affections which often bear an astonishingly close resemblance to them; and this discrimination, its essential principles being understood, is in most cases not difficult.

The first essential in this diagnosis is complete and accurate observation.

As our patients are mostly children, the laryngoscopic and rhinoscopic mirrors are for obvious reasons not usually very available, nor are they generally necessary, though in some cases, especially in older patients, they may give valuable information.

The patient should be placed for examination directly in front of a window or a good artificial light—if a young child, on the lap of his nurse. Thorough inspection of the throat is now in most cases easy. But some young children will oppose the operation. When this disposition is manifested the nurse should secure the patient's hands while some other person stands behind him and holds his head between the palms of the hands. Then, if the lips and teeth are compressed, the tongue-depressor (a smooth spoon-handle is one of the best) should not be thrust forcibly in, but held in readiness awaiting the opportunity which the child will soon give. It is then slipped deftly between the teeth and well back into the mouth along the dorsum of the tongue, when gentle pressure downwards will cause the child to open his mouth and give a view of the throat. The conformation of the mouth and throat is so different in different persons that it is now and then a matter of some difficulty to obtain a satisfactory view of the throat, especially if the patient resists or is inclined to vomit. In such cases some perseverance may be necessary. Repeated attempts with a little interval between them are less likely to excite vomiting than retaining the tongue-depressor in position too long at one time. The very act of "gagging" will throw the tonsils forward, giving a view of their posterior surface.

The throat having been thus thoroughly inspected, perhaps only redness and more or less swelling are observed. Do these denote the catarrhal or ante-membranous stage of diphtheria or some other inflammation of the throat? The probability of its being the former will be favored by the fact of previous exposure to contagion or the presence of an epidemic, and by certain characteristics of the throat-inflammation, especially a certain intensity and a somewhat abrupt limitation to a particular location, as one tonsil or one faucial pillar or a portion of the soft-palate; but it is only occasionally that this evidence is very significant. Other forms of throat-inflammation, as the follicular, are often one-sided, and I have seen the aspect of the throat in diphtheria a few hours before the appearance of membrane in no way distinguishable from that of many ordinary sore-throats. Hence a positive diagnosis of diphtheria can but rarely be made at this stage.

But suppose that we see on the inflamed mucous membrane of the throat whitish, yellowish or grayish appearances which at the first view more or less resemble false membrane. It is safe to say that a diagnosis of diphtheria or of "diphtheritic sore-throat" based simply on them would in the large majority of cases be erroneous.

It may be remarked in passing, that the phrase, diphtheritic sore-throat, may indeed have a legitimate use to convey a definite and well-understood meaning; but it has far too commonly been vaguely and indiscriminately applied in the absence of a positive diagnosis to various mild diphtheroid affections, most of which are, in no true sense of the word, diphtheritic.

The one pathognomonic sign of diphtheria is diphtheritic false membrane. The existence of diphtheria without a *diphthera* is indeed asserted. The reasons for regarding its occurrence as improbable have been elsewhere given. The distinctive characteristics of diphtheritic false membrane have elsewhere been stated. This membrane in the fauces and pharynx is never altogether superficial to the mucous membrane. Though the depth to which it involves the epithelial layers varies greatly in different cases, yet even in its most superficial form it is so intimately connected with the subjacent tissues that if it be scraped or torn away, a raw and bleeding surface is exposed.

In non-diphtheritic pharyngitis we often see whitish patches of pultaceous follicular secretion or smearings of glairy tenacious mucus, or ulcers of various kinds covered over with, or surrounded to some little distance by, yellowish or grayish muco-pus, or, in some cases, with a superficial and fragile membranous formation which is undoubtedly a true fibrinous or croupous exudation. These forms of ulcerative pharyngitis have been variously designated as "ulcero-membranous angina" by Da Costa,[1] "common membranous sore-throat" and "herpetic sore-throat," by J. Solis-Cohen,[2] "confluent herpes of the throat" by Morell Mackenzie,[3] and "drain-throat," a form of septic sore-throat attended with ulceration, by S. Solis-Cohen.[4]

The appearances presented by these affections may at the first view be very deceptive to the inexperienced eye; but their true character may be readily ascertained by brushing them with a swab, or, still better, throwing a stream of water upon them from a syringe. In aphthous or herpetic angina the little vesicles and the resulting ulcers are readily recognized when clearly exposed to view by this method, and the fibrinous pellicles just referred to have entirely vanished from the scene, or just enough fragments of them remain to make clearly evident their fragile, superficial and non-diphtheritic character.

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[1] "Medical Diagnosis," Phila., 1881, p. 431.

[2] "Diseases of the Throat," New York, 1879, p. 103.

[3] Op. cit., p. 52.

[4] "The Diphtheroid Throats," Archives of Pædiatrics, February, 1888, p. 92.

But by far the most frequent occasion of error in diagnosis is the very common affection known as acute follicular or lacunal tonsillitis. The tonsils are irregularly ovoid bodies, the surface of which is penetrated by a varying number of slit-like or circular orifices of a system of internal cavities, crypts or lacunæ, from which numerous follicles branch out into the substance of the gland. "The crypts of largest size and greatest depth are as a rule found in the middle part of the tonsil. (See figure 9.) The crypts are generally filled more or less with a yellowish substance composed of fat molecules, loosened pavement epithelium, lymph corpuscles, small molecular granules and cholesterin crystals, which probably proceed from retained and decomposed epithelial matter, and perhaps now and then from the bursting of follicles whose cells have increased by proliferation and have undergone a retrograde metamorphosis and fatty degeneration."[1]

Acute follicular tonsillitis occurs sporadically in connection with ordinary catarrhal pharyngitis, endemically from various local insanisary conditions, and epidemically. In this last form it is undoubtedly a specific disease, and is probably in some degree contagious. I have been led to this last conclusion from having so often seen it go through families of children, successive cases occurring at intervals of one, two or three days, just as occurs with diphtheria or scarlatina.

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[1] From "The Tonsils, their General, Surgical and Minute Anatomy," by D. Bryson Delavan, M.D., Archives of Laryngology, December, 1880.

Follicular tonsillitis is not a milder grade of diphtheria, but is a totally distinct disease. Diphtheria, it is true, may supervene upon follicular tonsillitis, as upon other catarrhal affections, but then it is usually, at least, only after the latter has run its course. As this requires only a few days, it is not strange that the two affections have been supposed by some to be related.

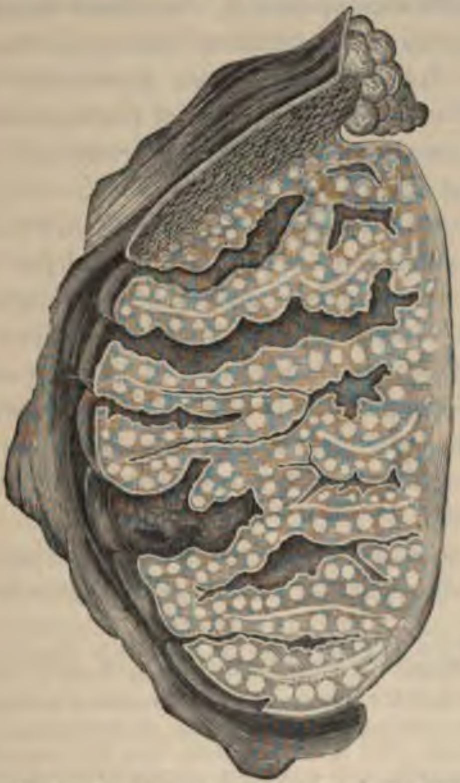

FIG. 9.—Hypertrophied Tonsil. (Enlarged drawing, Luschka.) This figure shows the position of the lacunæ and their orifices in the tonsil, as is above described.

Follicular tonsillitis differs from diphtheria in not causing constitutional poisoning, either septic or specific. It is not accompanied with nephritis (except as any febrile catarrhal affection may occasionally be); it is not followed by paralysis, and I have never known of a fatal case.[1]

The onset of follicular tonsillitis is undistinguishable from that of diphtheria in the amount of febrile and nervous disturbance which accompanies it. Its second stage, that of follicular exudation on the inflamed tonsil, may closely resemble diphtheria. Its third stage, which occurs after two or three days, is that of the disappearance of this exudation, exposing in its place peculiar appearances of erosion or excavation in the surface of the tonsil.

In the second stage, or that of exudation, we may often see whitish or yellowish points projecting, or liquid oozing from one or more of the lacunal orifices of the tonsils. The diagnosis is then easily made, for these appearances are pathognomonic of follicular tonsillitis. It is made easy in other cases by the evidently soft and pultaceous character of the deposit on the tonsil, and by its lying loosely and superficially on its surface, from which it is easily removed by rubbing it with a swab.

There is a smaller proportion of cases, but yet very numerous in the aggregate, in which the diagnosis is much more difficult. These cases are thus described by Dr. Geo. M. Lefferts:[1] "Have you not often seen in these cases of follicular tonsillitis an aggregation of the grayish-white pultaceous masses which block up the mouths of the diseased and occluded crypts to such an extent that not only is an apparent, but a real pseudo-membrane formed—one thickened by the products of cellular growth and decay (fungi and bacteria) and rendered coherent by the inflammatory hyperplasia? A membrane which may occupy only part of the tonsillar surface appears here and there in patches, or, more rarely, still not infrequently, covers it entirely. The appearance is not an unusual one, and the attendant constitutional disturbance well-known."

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[1] In the Section on Practice of the New York Academy of Medicine, Dr. J. Lewis Smith (see New York Medical Record, Nov. 27th, 1886) stated as the result of his large observation of the two diseases his belief that they are not related, except that diphtheria may occur as a secondary disease. Dr. L. Emmet Holt, from the observation of three hundred recorded cases of tonsillitis, concurred in this view. Dr. Holt also quoted Dr. Haig-Brown, medical officer to the Charterhouse school in England, who had in three years met with four hundred and sixteen cases of tonsillitis among the five-hundred boys who were under his supervision, but only one case of genuine diphtheria, and who had recorded two epidemics of simple tonsillitis in which the disease was unquestionably spread by contagion, and Dr. G. A. Spalding of this city, who had stated that at the House of Refuge cases of tonsillitis were constantly occurring, yet no clear case of diphtheria had been seen there in years, and Dr. Gibney of this city, who had made a similar statement in reference to the Hospital for the Ruptured and Crippled during his term of service there.

Dr. Lefferts in this connection refers also to the infectious catarrhal tonsillitis which has been described by Fox and other English writers, under the name of "spreading quinsy," which is essentially an inflammation of the tonsils, extending more or less into the pharynx, and, sometimes, to the neighboring submaxillary and cervical glands. It is essentially a filth-disease, is communicable, is attended with a certain amount of anæmia and depression, the mortality from it is slightly greater than from ordinary tonsillitis, and it is never followed by paralysis. According to Fox's observations it is never accompanied with a well-marked membrane. In this respect my own observations have differed from those of Dr. Fox, as I have seen more than one epidemic of an affection answering in all other respects to the description just given, in which the occurrence of quite a firm membranous formation on the tonsil was not uncommon.

While the patches in follicular tonsillitis are more usually composed of the conglomerate follicular exudation above referred to, spread out and inspissated, they are not infrequently either wholly or in part a true fibrinous or "croupous" membrane. These two elements are often intermingled. The fibrinous form has been regarded and described by some as a separate affection from follicular tonsillitis, under the name of croupous tonsillitis. Though some cases apparently justify this discrimination, yet my observation, which has included a great number of cases, has led me to regard them as being, usually, at least, simply different forms of the same affection. The other view is taken by Dr. L. Emmet Holt in a very valuable paper on the subject;[1] but the following passage in Dr. Holt's paper would seem to favor my own conclusion. Having referred to other designations given to this affection ("spreading quinsy," "catarrhal diphtheria," etc.), Dr. Holt continues, "I prefer, with Carmichael,[2] to regard them as cases of croupous tonsillitis. This writer describes the pathological appearances in the following words: 'The gland is a pale red; the patch of a yellowish-white color, confined to the tonsil, easily separated, leaving a loss of epithelium, but the gland otherwise intact. Microscopically, *besides the cell-elements of follicular tonsillitis*, blood-corpuscles in a fibrinous matrix are present.'" The italics are mine. Yet my own observations accord with those of Dr. Holt that in some cases the fibrinous or "croupous" element in the affection is the only noticeable feature. Our observations agree upon the important points that it is limited to the tonsil, that it closely resembles diphtheria, for which it is doubtless very often mistaken, and that it is not diphtheria. Indeed the only explanation of the fact that the descriptions of this very common affection in medical literature are so few and, with a few exceptions, so incomplete, is that it has been regarded by a large proportion of observers as a form of diphtheria. The error is a very natural one.

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[1] "Some of the Commoner Affections of the Tonsils," New York Medical Record, 1879, 16, p. 601.

The following case is described by Dr. Holt and stated to be one of nineteen in all essential respects similar to it of which he has notes: "On November 11, I saw a stout well-nourished girl of ten years, who was reported to have been perfectly well until the morning of that day. She was taken at eleven o clock with a chill, vomited twice, complained of pains in the chest and seemed quite sick. The temperature, when seen three hours later, was 103.2° F., pulse 140, respiration 32. Examination of the chest revealed nothing abnormal, but on inspecting the throat the tonsils were found much swollen, and the right completely covered by a thick yellowish gray membrane, the left being about two-thirds covered. On the following day the temperature was 102.4°, the membrane was still distinctly circumscribed, showing no tendency to spread, but was more yellow in color. On the third day the temperature was 101.6°, and after that it was normal. On the fourth day the throat was practically well."

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[1] "The Non-identity of Croupous Tonsillitis with Diphtheria," Transactions of the Medical Society of the State of New York, 1886, p. 552.

[2] Edinburgh Medical Journal, July, 1884.

This case is a graphic illustration of what I have seen in numerous instances, and have referred to in previous publications, the first having been in 1880. In that paper I referred to cases which I had observed of even a more deceptive character than the one just described, as follows: "In occasional instances nearly the whole surface of the tonsil is covered with a thick and firm investment of this character. If this appearance is accompanied, as it sometimes is, with grave constitutional disturbance, distress and prostration; if there is some enlargement of cervical glands; if the throat is filled with tenacious muco-pus, perhaps rendered sanious by points of ulceration; if there is fœtor of the breath; if on the uvula or the faucial pillars are the whitish smearings above referred to, the physician who has not studied this subject carefully and well naturally supposes that he has to do not only with a case of diphtheria, but a grave one, and is delighted at his success in curing it in two or three days, as he is certain to do."

But it may be asked, what ground of certainty is there that such a case is not in reality diphtheritic? I answer, this—

that having recognized its true character by the methods now to be stated, we can accurately predict the subsequent course of events, which is that it will not extend beyond the tonsils, and that after two or three days the diphtheroid deposits will have vanished, leaving in their place the typical appearances of erosion or excavation in the tonsil, and that there will be none of the distinctive constitutional symptoms, nor the sequelæ of diphtheria.

How shall the differential diagnosis be made? Not by the circumstance that the exudation is limited to the tonsil or tonsils, for that is often true in diphtheria; nor by its short duration, for that is equaled by very mild forms of diphtheria; nor by the severity or mildness of the accompanying febrile disturbance, for that varies greatly in both affections; nor by the test of infection or non-infection, for catarrhal tonsillitis is sometimes infectious; nor even by the presence or absence of albuminuria, for reasons which have been elsewhere stated.

We are told by various writers that the diagnosis of follicular tonsillitis may be made by scraping the membraniform investment from the tonsil, or forcing out the cheesy contents of the crypts by pressure, or thrusting a probe into the distended lacunal orifices, which methods in the case of a suffering and struggling child are unnecessarily heroic.

In the paper from which I have just quoted I called attention to two points or methods in this diagnosis, of which experience had taught me the valuable practical utility, and the added experience of subsequent years has only tended to confirm my estimate of that utility.

The first of these points is the *location* of the membraniform patches in follicular tonsillitis. These patches being usually formed wholly or in part by exudation from the lacunal openings, or being at least the result of an inflammation which involves the follicular portion of the tonsil, are in relation to those openings, and are consequently located on the more central portion of the convexity of the tonsil which is the site of the principal and most numerous openings. (See figure 1, page 134).

On the other hand, a patch of true diphtheritic membrane when it is limited to the tonsil is not usually seen on that portion of its surface only, but occupies a more lateral or marginal position, the true diagnostic point being the relation or want of relation to the lacunæ of the tonsil. Hence, if on the first inspection of the throat a membranous patch is seen covering the central portion of the convexity of one or both tonsils, and is limited to the tonsil, it may be regarded as very probable that the affection is follicular tonsillitis rather than diphtheria; while a membranous patch, however small and slight in appearance, which is seen on the marginal portion of the tonsillar surface, and is evidently not in relation to the lacunal orifices as its source, should be carefully investigated.

I have seen true diphtheritic membrane in its formative stage extending in slight streaks or spots across the tonsil. In those instances it has been easily to be seen that the streaks or spots did not emerge from the lacunal openings, and bore no relation to them, which is, in reality, the essential point to be ascertained.

The second method is syringing the throat with warm salt-water. In follicular tonsillitis this will cleanse the throat of much deceptive material. The membraniform covering of the tonsils will be in part at least broken up and washed away, showing its friable and superficial character, and its relation to the distended lacunal orifices. A prompt and accurate diagnosis is thus made practicable by a simple and readily available method in many cases in which it would otherwise be difficult or impossible.

Like most other "ready methods" in diagnosis, those which I have now mentioned require to be used with due reserve and discretion, especially by inexperienced physicians and at times when diphtheria is epidemic. It cannot be denied that there are cases in which the most competent and experienced physician must reserve his positive diagnosis for a day or two, and rare instances in which some doubt must remain even after the most careful consideration of all the attendant circumstances. Yet the number of cases in which these tests when applied *with accurate observation* will fail is surprisingly small. This, I am sure, would be testified to by any one of at least twenty physicians who, during the past fifteen years as my assistants in the out-door visiting at Demilt Dispensary, have had frequent occasion to apply them, and some of whom are now well known in the profession. I have by the application of these methods in numerous cases, both in dispensary and private practice, been enabled to dispel the alarm occasioned by very formidable "diphtheritic" appearances by assuring the sufferers or their friends of their probably innocent and transient character, and have been justified by the event. I have also been called in consultation in quite a number of cases of supposed diphtheria of some severity and danger, in which I have from the same considerations been enabled to assure the attending physicians that their patients would in all probability make a rapid and complete recovery, frankly stating to them the diagnostic grounds of my belief, and the prediction has in every instance been verified.

I have under other circumstances personally known of not a few instances in which follicular tonsillitis has been mistaken for diphtheria by intelligent, conscientious and not inexperienced physicians. While this error is greatly to be deprecated, not only on account of the needless alarm and inconvenience which it is liable to occasion, but still more because, as has unfortunately been but too widely illustrated in the literature of diphtheria, it renders in proportion to its frequency the teachings of therapeutical experience worthless or misleading, the opposite error of the mistaking of diphtheria in its mildest forms or its slight beginnings, for its benign counterfeit, may, in its immediate results at least, be even more disastrous.

It hardly needs to be remarked that while the diagnosis is in any degree doubtful, the patient should be isolated, and the case treated as one of tonsillar diphtheria.

The following case illustrates certain other elements of interest, which may sometimes attend this differential diagnosis: In 1881 I saw, in consultation with two well-known physicians, the little daughter of another well-known physician of this city. She was suffering with a violent inflammation of the throat, accompanied with exudation upon the tonsils. There was also laryngeal stenosis, so grave that the necessity of tracheotomy was imminent. The question under anxious consideration was, Is the tonsillar disease follicular or diphtheritic? After a careful examination, and with some hesitation on account of the gravity of the case, I concurred with one of the other consultants in the view that it was follicular, and on that diagnosis we based a favorable prognosis for the impending tracheotomy, believing that the laryngeal affection would prove to be catarrhal. The operation presently became necessary, It had a successful result, there being no evidence of the presence of false membrane in the larynx or trachea. At the same time the little sister of the patient was violently attacked as she had been, except that there was no laryngitis. The latter case proved unusually grave and persistent, with serious constitutional disturbance and depression, but yet progressed and terminated as follicular tonsillitis. It should be added that in the residence of these patients—a "first-class" one on Madison Avenue—there were found to be serious defects in the plumbing. This case is illustrative of the importance of an accurate diagnosis in cases requiring tracheotomy in order to give real value to statistics of the results of that operation in diphtheritic and non-diphtheritic cases.

EXPLANATION OF THE FOLLOWING PLATE.

Figure 1 shows a usual and easily recognizable form of follicular tonsillitis in a woman thirty years of age on the third day of her illness. The characteristic location of the exudation and its evident relation to the lacunal orifices are here illustrated.

Figure 2 depicts tonsillar diphtheria in a girl ten years of age on the third day of her illness. She was one of seven members of one family in the Willard Parker Hospital for Contagious Diseases who had been attacked nearly simultaneously, including the mother and five other children. In the mother and the four elder children the affection was limited to the tonsils and was mild in character. A child about three years of age had diphtheria of the tonsils, soft palate and nares, from which she recovered. The youngest—an infant—was intubated for laryngeal diphtheria, and died on the following day with the symptoms of the extension of the membranous affection into the bronchial tubes.

Figure 3 represents diphtheria of the soft palate and tonsils in a female patient twenty-six years of age, on the sixth day of the disease. The uvula, which in this case is small and unaffected, is nearly concealed from view by the swelling of the adjacent parts.

Figure 4 (from Dr. Lenox Brown's work on Diseases of the Throat) is a rhinoscopic view of the posterior nares in a fatal case of naso-pharnygeal diphtheria.

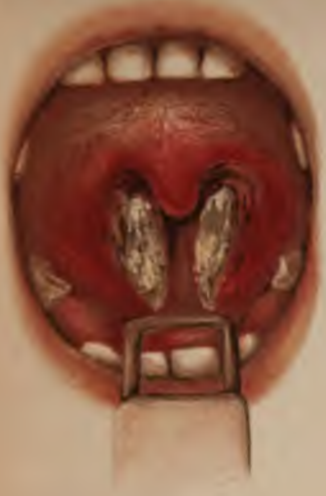

Figure 2.

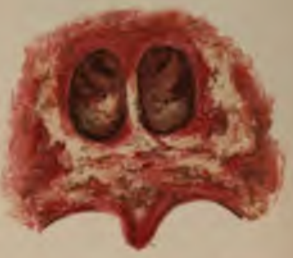

Figure 4.

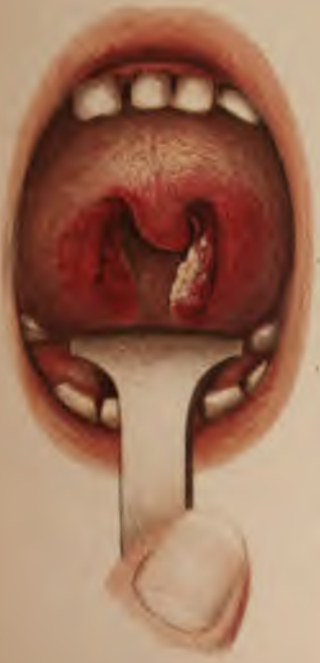

Figure 1.

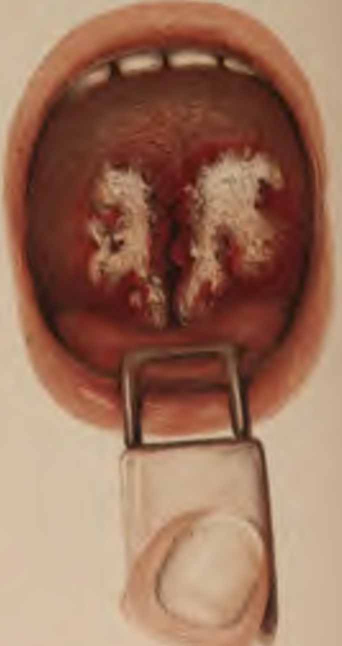

Figure 3

Lindner, Eddy & Claus, Lith. N. Y.

Scarlatina is another affection with which diphtheria is very liable to be confounded. This liability occurs usually in those cases of scarlatina in which the distinctive features of the disease, especially the eruption, are either absent or are so slight and ill-defined as to be overlooked, and in which pseudo-membranous exudation is present.

The distinctive features indicative of scarlatina are in the earlier stage the following: the fever is usually higher in scarlatina, especially in the malignant form without eruption; vomiting, common to both, is especially characteristic of the first onset of scarlatina. The well-known appearances of the tongue in scarlatina are usually more or less typical. The appearance of the throat formerly described by me[1] as characteristic of scarlatina,—namely, a bright diffused or punctate redness extending from one or both tonsils along the faucial half-arches to the uvula, and shading off more or less gradually on the soft-palate, is rarely altogether wanting. The diphtheroid form of scarlatinal angina, which is also characteristic, is described in the chapter on secondary diphtheria, to which the reader is referred.

At a later period the well-known tendency of scarlatinal inflammation to extend into the nares and into the middle ear is a very suggestive diagnostic feature, the latter region being very rarely invaded by primary diphtheria.

Albuminuria and nephritis are the more probably of a scarlatinal origin in proportion to the lateness of their occurrence, and also to their presenting certain features; as the presence of blood in the urine, which is frequent in scarlatinal and infrequent in diphtheritic albuminuria, and their being accompanied by subcutaneous œdema, of which the same is true.

The evidences of the invasion of the nasal passages by diphtheria have been described in the chapter on symptoms.

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[1] "Clinical Observations on the Early Stages of Scarlatina." Read before the New York Academy of Medicine. N. Y. Medical Record, March 23rd and 30th, 1878.

When this occurrence is thus made probable, but false membrane is not visible on ordinary inspection, the diagnosis may in some cases be readily completed by the use of the nasal speculum or the rhinoscopic mirror; but a universally available method is the syringing of the nares, as will be described in the chapter on treatment. This procedure will first demonstrate the occlusion of the nasal passages, and, if persevered in, will usually dislodge and bring away shreds or larger portions, of membrane.

When the symptoms of croup are preceded or accompanied by the presence of false membrane in the pharynx or nares, the laryngeal affection is, as a rule, pseudo-membranous. In cases in which they are not thus accompanied it is sometimes difficult to decide whether it is membranous or catarrhal. Positive evidence that it is the former may in some cases be obtained by the aid of the laryngoscope, and in some others is afforded by the coughing up by the patient of shreds of membrane. When an attack of croup follows exposure to the contagion of diphtheria, or occurs during an epidemic of that disease, it may be presumed to be membranous. Some children are by individual or family predisposition subject to attacks of catarrhal croup after taking cold. In such patients the recurrence of that affection is under ordinary circumstances more probable than the occurrence of membranous croup, though the latter is of course not impossible. A sudden onset, especially at night, is characteristic of spasmodic croup, and if it have not been preceded by symptoms of laryngitis warrants that diagnosis. Mere remissions in the symptoms, however, with sudden exacerbations, are by no means so conclusive, since a spasmodic element is sometimes very pronounced in the earlier stages both of catarrhal and membranous croup. The persistency and steady increase of serious croupal symptoms may be due either to membranous laryngitis or to severe catarrhal laryngitis. The former is the more usual cause in such grave cases, and is therefore the more probable one in any given case; yet in the absence of positive evidence of the existence of membrane the diagnosis can never be absolute, since some such cases have been found after tracheotomy or at the autopsy to be purely catarrhal.

Reasons have elsewhere been given for the belief that there is a membranous croup which is not diphtheria, but yet that under ordinary circumstances the two affections are so liable to be complicated or confounded that the diagnosis of the former can rarely be a positive one. This diagnosis must relate mainly to the following points:—Simple membranous croup is not traceable to the contagion or the endemic or epidemic influence of diphtheria, but to non-specific causes which are usually meteorological; it occurs by marked preference in the colder seasons of the year and in exposed situations; it is itself non-contagious; it is sporadic, or, if it occurs epidemically, does so as the evident result of special meteorological conditions; it is entirely or mainly limited to the air-passages; it is an acute local inflammation attended with fever which never becomes adynamic; it is never attended with the symptoms of diphtheritic or septic constitutional poisoning; it is fatal only by mechanical obstruction to respiration; it is never followed by paralysis.

The presence of croupous bronchitis may be regarded as probable when, in the course of laryngo-tracheal diphtheria, there is a marked increase in temperature and in frequency of respiration, with the physical signs of bronchitis and broncho-pneumonia; but the diagnosis can never be positive except from the evidence afforded by the coughing up of membranous casts of the bronchial tubes.

The unreliability of symptoms which point to the existence of œsophageal diphtheria has been referred to in the chapter on symptoms. Evidence afforded by the laryngoscope, or by the expectoration of membrane from that location, is the only basis of a positive diagnosis. Gastric or intestinal diphtheria can be positively recognized during life only from the vomiting or the voiding of its pseudo-membranous products.

When a paralysis with the characteristics which have been elsewhere described follows a recognized attack of diphtheria, there can be no question as to the diagnosis. In those cases in which the preceding disease has been unrecognized, the nature of the paralysis is usually made plain by the fact that it affects the palate only or mainly, or that having first attacked that organ it has successively invaded other parts in an order and in a manner which, though subject to variations, are yet typical of diphtheritic paralysis. A history of a preceding sore throat or coryza can then usually be obtained. In rare cases the palate may not have been affected, and the paralysis when it presents itself to the physician may have become more or less general, a considerable time having elapsed since the attack of diphtheria. Even in such a case there are usually evident characteristics of diphtheritic paralysis in the history of its gradual progress from one part to another, one having wholly or partly recovered its strength as others have become weak, in the disturbances of vision and the strabismus, and even in the fact that when the palate is not at first affected, it is often attacked at a later period. Even when it most deviates from the usual order of occurrences there is in its very capriciousness and irregularity, in its incompleteness, in the intermingling of sensory disturbances with motor paresis, a physiognomy which is recognizable from that of most other paralyses. Diphtheritic paralysis of the extremities may simulate locomotor ataxia in the incoördination of movements and the loss of the knee-jerk, but it may usually be distinguished from that affection by its more rapid onset, by the greater muscular weakness and by the absence of the characteristic pains. It differs from simple paraplegia in its history, in the loss of the knee-jerk and in its comparatively short duration. In acute atrophic paralysis the change in electro-muscular contractility is usually much greater, and there is no disturbance of sensation. In hysterical paralysis the palate is never affected.

CHAPTER IX.

PROGNOSIS.

DIPHTHERIA has always been justly regarded as a most dangerous disease. In many recorded epidemics a large majority of all cases have proved fatal. Even at the present time, and in spite of all our therapeutic progress, its general fatality continues to be very great.

The proportion of deaths from diphtheria to reported cases of the disease in this city during the eight years, 1880 to 1887, inclusive, according to the returns of the Board of Health, is shown in the following figures, for which I am indebted to the courtesy of Dr. John T. Nagle:

Year.	No. of Cases.	No. of Deaths.	Percentage of Deaths.
1880	3307	1390	42.03
1881	5272	2249	42.65
1882	3507	1525	43.48
1883	2906	1009	34.37
1884	2201	1090	49.47
1885	2920	1325	45.37
1886	3737	1727	46.21
1887	5923	2167	36.58
Average			42.62

The statistics of the disease in Boston during the same period, which have been kindly given me by Dr. John H. McCollom, City Physician, are somewhat more favorable:

Year.	No. of Cases.	No. of Deaths.	Percentage of Deaths.
1880	1715	588	34.2
1881	1680	601	35.7
1882	1386	458	33.04
1883	1415	445	31.4
1884	1212	345	28.46
1885	1263	334	26.44
1886	1188	329	27.69
1887	1049	316	30.12
Average			30.88

It is justly objected to the conclusions from such statistics that not all the cases of diphtheria are reported; but in view of what has been remarked in the preceding chapter as to the unquestionable frequency of errors in diagnosis, it is very probable that the deficiency referred to has been at least compensated for by the reporting of milder forms of disease as diphtheria. In 23 of the 1049 cases reported as diphtheria in Boston in 1887, the error in diagnosis was so palpable as to be noted by the Sanitary Inspectors, who can hardly be supposed to have been hypercritical, under the heading, "Mistake in the report made by physicians."[1]

In some statistics in which no error is possible, the terrible fatality of the disease is even more strikingly indicated. Thus, in three hundred and nineteen cases in the wards of the Royal Charité Hospital in Berlin, reported by Henoch[2] in 1885, two hundred and eight, or 65.5 per cent., were fatal. According to the statistics of the Hospital Trousseau, Paris, for the year 1883,[3] of 606 cases of diphtheria treated, 391 died, or 64.5 per cent. On the other hand, medical literature abounds in reports of large numbers of cases of diphtheria, some of which will be subsequently referred to, in which under very various modes of treatment recovery has been the invariable result or nearly so. The possible sources of error in such enumerations are elsewhere considered.

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[1] "Report of the Board of Health of the City of Boston for 1887," p. 25.

[2] Charité Annalen, vol. x., p. 490.

[3] Archives of Pædiatrics, 1884, p. 321, from Rev. Mens. des Mal. de l'Enf., February, 1884.

The estimate is probably within bounds that at least thirty per cent. of all cases of genuine diphtheria terminate fatally, though, of course, in many groups of cases the mortality is very much less.

In so far as the prognosis in diphtheria is based on general conditions, it is less favorable in that which is epidemic than in that which is endemic or sporadic. It must also vary according to the general character of the prevailing epidemic, since some epidemics are much more severe and fatal than others. It is less favorable at the outset or the height of an epidemic than during its decline. It is less favorable in the country than in cities; in the colder seasons of the year than in summer; in insanitary conditions than in opposite ones. It is also in the same degree of severity of the disease much less favorable in the cases of children under three or four years of age than of older patients.

The prognosis in a case of diphtheria must at its onset be a guarded one, since the subsequent extent and character of the disease can never be positively predicted from the symptoms at that stage; yet severity in the early local and general manifestations of the disease is of comparatively unfavorable prognostic import, while mildness is correspondingly favorable.

Since the dangers to be chiefly apprehended in diphtheria are two, namely, pseudo-membranous obstruction of the air-passages and constitutional poisoning, the prognosis must be based on the greater or less tendency of the disease in each particular case to produce one or the other or both of these results.

The commencement of the disease in the larynx, or the subsequent occurrence of the symptoms of croup, is of most unfavorable portent. When no symptom of the extension of the disease thither has appeared by the third day from the attack, the chances of escaping it may be regarded as fair, and they improve by a rapidly increasing ratio with each subsequent day's immunity, until the sixth or seventh, when they may be regarded as very favorable. The prognosis in laryngeal diphtheria is especially unfavorable when the symptoms of that affection are accompanied with those of constitutional poisoning, or when, either before or after tracheotomy or intubation, there are evidences of the presence of bronchitis, tracheal and bronchial diphtheria, broncho-pneumonia, lobar pneumonia or pulmonary œdema.

In diphtheria in which the larynx is not involved the prognosis is unfavorable in direct proportion to the gravity of the local affection, as manifested in the intensity of the inflammation, and the extent and more especially the depth of the pseudo-membranous formation and its occurrence in locations which are most favorable to toxic absorption.

If the fever which was high at the outset continues high for some days, or if, having been moderate, it becomes persistently high, its significance is unfavorable, because it denotes that the disease is severe and progressive or that some serious complication exists.

Adenitis is of unfavorable significance in proportion to its amount and the rapidity of its development.

The symptoms which have been elsewhere described as especially indicative of constitutional diphtheritic poisoning, such as pallor, prostration, somnolence, anorexia, etc., are of bad prognostic import in proportion to their gravity, the earliness and rapidity of their development and their persistency in spite of appropriate treatment.

Vomiting, when it begins and continues at a later stage of the disease, in connection with marked anorexia, and is not merely the result of inappropriate medication, stimulation or feeding, is an evidence of profound constitutional poisoning and is a bad omen.

Marked weakness of the pulse and indistinctness of the heart-sounds with excessive rapidity or slowness, especially when accompanied with irregularity, are premonitory or indicative of heart-failure. Endocarditis is also a very unfavorable complication.

The importance of albuminuria varies according to its gravity and other circumstances which have been stated in the chapter on symptoms.

Delirium, when it is merely the accompaniment of high fever in the earlier stages of the disease, is not necessarily of the most serious import, but when it occurs in connection with symptoms of grave septic and uræmic poisoning, and with other evidences of resulting meningeal or cerebral implication, is too often the precursor of a final coma.

Purpura hæmorrhagica occurring in the course of diphtheria is usually of fatal import.

Gangrenous diphtheria, although always a grave form of disease, is not, under suitable treatment, the hopeless one which some authorities have pronounced it. In quite a number of cases which have been included in my experience the majority have recovered.

Nasal diphtheria, which has been considered by some good authorities as almost necessarily fatal, may under suitable treatment be regarded much more hopefully, as it undoubtedly admits of cure in the majority of all cases. The danger which it involves is proportionate to the amount and persistency of the pseudo-membranous affection of the nasal passages, and to the amount of constitutional poisoning which has already taken place. This danger is markedly increased by the occurrence of epistaxis, which, when serious and persistent is a most unfavorable complication.

When the various local and general manifestations of the disease which have now been referred to take place with that impetuous and overwhelming rapidity which constitute its malignant form, the prognosis is grave indeed.

In the mild grade of diphtheritic paralysis, limited mainly to the soft palate, which is seen in the large majority of cases, the prognosis is favorable both as to a brief duration of the attack and its involving no serious danger to life. In other cases the prognosis in respect to both these circumstances varies according to the severity of the attack, the earliness with which it follows the primary disease, and the parts which it affects. When the initial paralysis of the palate proves to be unusually severe and persistent, it becomes probable that the limbs will also be affected, and when the paresis in them is especially grave, it is likely that the upper extremities will not escape. Under these circumstances the duration of the attack instead of from two to six weeks will be as many months. As a general though not an invariable rule the degree of paralysis is in some direct proportion to the closeness of its sequence to the primary disease.

Danger to life from diphtheritic paralysis is proportionate to the degree of its interference with heart action, respiration or deglutition. Definite symptoms of cardiac paralysis occurring within a week or two after the onset of diphtheria are too often of fatal import. The danger from paralysis of the respiratory muscles is greatest when both the intercostals and the diaphragm are affected. Its degree is in proportion to that of the dyspnœa and of the accumulation of mucus in the bronchial tubes. In serious paralysis of the pharynx and the larynx there are the dangers of inanition from the difficulty of swallowing food and the repugnance to attempting it, and of suffocation or pneumonia from portions of food entering the air-passages.

CHAPTER X.

PROPHYLAXIS.

THE prophylaxis of diphtheria must consist in preventing, removing, or avoiding as far as possible its general and special causes. These have been referred to in the chapter on etiology.

It follows that in selecting a residence all possible care should be taken to avoid the conditions which predispose to the disease, such as damp situations, unsusceptible of drainage, the vicinity of stagnant and polluted water, etc. The greatest attention should be paid to preventing the contamination of drinking-water. Too many shade-trees about a house are undesirable, and every pains should be taken to secure an ample supply of sunlight in the dwelling-rooms as well as thorough ventilation, and cleanliness in and about the habitation. The habitual use by children of abundant and wholesome food is of great importance. Since many attacks of diphtheria follow catching cold the greatest attention should be paid to the suitable dressing of children, the prevention of damp feet, etc. Careful attention must also be paid to the ventilation, warming and general sanitary condition of the school-houses which they attend.

The securing of the enactment of proper sanitary regulations in towns and villages and their faithful enforcement by the authorities should be regarded as a most important duty by every citizen. The removal of the conditions which favor disease, such as overcrowding, filth, etc., from the tenement-houses and hovels of the poor, might prevent many an epidemic which from those sources invades and devastates the homes of the more fortunate classes.

During the prevalence of an epidemic, especial attention should be paid to everything which relates to the health of children. Their throats should be frequently inspected. Their colds and catarrhs should receive prompt treatment. It should be remembered that decaying teeth and coated tongues may furnish a nidus for disease-germs. If there is a tendency to relaxed conditions of the mucous membranes the mouth and throat may be frequently washed, gargled or sprayed, or the nasal passages syringed or sprayed with some mild antiseptic and astringent liquid such as will be mentioned in the next chapter. Depressed conditions of the general health should be promptly corrected by the use of suitable tonics, especially iron. At such times, also, the greatest vigilance should be used by teachers, parents and the public authorities to prevent the introduction of the disease into schools or to ensure its prompt recognition should that occur.

When a case of the disease occurs in a family, the patient should at once be strictly isolated—preferably in a room at the top of the house, which should be capable of free ventilation and exposed to direct sunlight. All unnecessary furniture, especially hangings and upholstery, should first be removed from it. Should there be reason to suspect unfavorable endemic conditions, the well children should, if practicable, be sent away until the danger of infection is over. In any case they should be kept under the vigilant supervision of a physician. Their throats should be inspected twice daily, and the preventive local and general measures just referred to should be promptly employed when indicated. I have, in many cases of children who had been exposed to the contagion of diphtheria, or were continuously exposed to it, directed that the tincture of iron mixture or that of iron and the chlorate of potassa, of which the formulæ will be given in the next chapter, should be administered every two or three hours, and have had reason to think that the result has been advantageous.

Nurses who attend upon the sick should be kept isolated from the children of the household.

The danger of the emanation of diphtheritic poison from the sick and the consequent infection of others will be greatly diminished by the employment of the local antiseptic treatment of the disease, which will be described in the next chapter, and of thorough measures of cleanliness, ventilation, etc. The records of 201 dispensary cases, including many very severe ones, thus treated by me,[1] in which little or no separation of the sick from the well was practicable, show that 2 occurred together or consecutively in the same family in eighteen instances, 3 in five instances, and 6 in one instance, while 144 were solitary cases subsequently to the commencement of antiseptic treatment, although not a few of them had been preceded by other cases under other treatment.

In case of death from the disease the corpse should be placed in an air-tight casket, the burial take place promptly and the funeral be strictly private.

The following are from the "Instructions for Disinfection" issued by the Health Department of this city in 1888:

I. DISINFECTANTS TO BE EMPLOYED.

1. Roll Sulphur (brimstone) for fumigation.

2. Sulphate of Zinc and Common Salt dissolved together in the proportion of four ounces of the former and two ounces of the latter in a gallon of water; for clothing, bed-linen, etc.

3. Sulphate of Iron (copperas) dissolved in water in the proportion of one and one half pounds to the gallon; for soil, sewers, etc.

4. Corrosive Sublimate Solution. Made by dissolving bichloride of mercury in the proportion of eight grains to the

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[1] See New York Medical Record, April 9th, 1887, p. 399.

pint of water. To the discharges of a sick person should be added an equal quantity of the solution.

II. How to Use Disinfectants.

1. The clothing, towels, etc., should, on removal from the patient, and before they are taken from the room, be placed in a pail or tub of the zinc solution, boiling hot. All discharges should be received in vessels containing the corrosive sublimate or the copperas solution. When that is impracticable they should be covered immediately with the solution. All vessels used about the patient should be cleansed with the solution.

2. For fumigation the rooms to be disinfected must be vacated, and closed as tightly as possible, stopping up chimneys, ventilators, etc. Place the sulphur in iron pans supported upon bricks placed in wash-tubs containing a little water; set it on fire by means of hot coals or with the aid of a little alcohol poured over it. Allow the room to remain closed for twenty-four hours; then open all windows and air thoroughly.

Heavy clothing, bedding and other articles which cannot be treated with the zinc solution should be hung in the room during the fumigation, their surfaces thoroughly exposed. Care should be taken to have woolen and cotton goods free from moisture, or the sulphur fumes will injure them. Pockets should be turned inside out. Afterwards the articles should be hung in the open air, and thoroughly beaten and shaken.

Pillows, beds, upholstered furniture, etc., should be cut open, the contents spread out and fumigated. Carpets are best fumigated on the floor, but should afterwards be removed to the open air and thoroughly beaten.

For fumigation at least three pounds of sulphur should be used for every thousand cubic feet.

3. Body and Bed Clothing, etc.—It is best to burn all arti-

cles which have been in contact with persons sick with contagious or infectious diseases. Articles too valuable to be destroyed should be treated as follows:

(*a*) Cotton, linen, flannels, etc., should be treated with the boiling-hot zinc solution. Introduce piece by piece to secure thorough wetting, and boil for at least half an hour.

(*b*) Heavy clothing, etc., should be treated as described under the directions for fumigation.

4. Water-closets, privies, sewers, etc., should be frequently and liberally treated with copperas solution.

At a meeting of the Michigan State Medical Society[1] the secretary demonstrated in a tabulated statement accompanied with a graphic chart the extent to which isolation and disinfection had reduced the number of cases of diphtheria and the number of deaths therefrom in the various outbreaks reported by local health-officers during the year 1886. In 102 outbreaks in which there was a neglect of one or both of these measures, the average number of cases to the outbreak was a little over 16, and the average number of deaths 3.23; while in 116 outbreaks in which both were enforced the average number of cases was 2.86, and that of deaths 0.66. In other words these simple precautions reduced the number of cases occurring during the year by 1545, and the number of deaths by 298.

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[1] New York Medical Journal, May 21, 1887, p. 580.

CHAPTER XI.

TREATMENT.

GENERAL INDICATIONS.

THE factors which are to be dealt with in the treatment of diphtheria are, as has already been seen:

1. A parasite which is implanted on or in the mucous membrane or other affected surface, and there produces the poison which causes the disease.

2. A specific inflammation which is excited thereby, and which has the two following results:

(*a*) The reproduction and local dissemination of the poison, and

(*b*) The production of a false membrane which, though itself inert, does harm in two ways, namely, by shutting in the poison and preventing its removal and thus favoring its absorption, and also in certain situations by interfering mechanically with vital functions, especially respiration.

3. The absorption of the poison or poisons into the circulation, and the production thereby of a general disease which is characterized by a tendency to adynamia and the occurrence of various organic lesions.

The principal general indications which have to be met in the treatment of diphtheria, are, therefore, the following:

1. To destroy, remove, or limit the action of the invading poison. Measures for this purpose include the employment of a great variety of agents and processes for local disinfection and for the removal of the false membrane and also of internal medication to promote the same objects.

2. To subdue or limit the inflammation. Measures for this purpose are both local and general.

3. To obviate the occlusion of the air-passages by false membrane. Measures for this purpose are surgical and mechanical.

4. To promote the elimination and counteract the effects of poison which may have been absorbed.

5. To economize and sustain the vital forces in their combat with the disease.

6. To avert or combat the morbid effects of the disease upon particular organs, and other special dangers which may in any case arise during its course.

GENERAL PRINCIPLES OF TREATMENT.

The practicability and the relative importance of each of these indications, and the choice of means for its accomplishment, vary in different cases according to many circumstances, among which are the type, the stage, and the localization of the disease and the age and constitution of the patient. No merely routine method, therefore, can be indiscriminately employed, but the treatment must be intelligently adapted to the circumstances in each particular case.

The fulfilment of the first and most obvious of the indications just enumerated is in practice opposed by difficulties which are often grave and sometimes insuperable, arising from the inaccessible location of the affection in many cases, the opposition made to our efforts by young children, and the fact that the parasite which causes the disease, except in its mildest forms and earliest stages, lies not merely on the affected surfaces, but within their more superficial tissues and in inaccessible recesses, while in not a few instances complicating septic organisms have become widely distributed through the system. In such cases successful efforts at local disinfection must often be limited to diminishing in some degree the growth and vital activity of the pathogenic organisms rather than their eradication, to softening and thinning the false membranes rather than their complete destruction, and to diluting and washing away some portion only of the chemical poison of the disease, and thus diminishing, though not entirely preventing, its absorption. When the disease in its grave forms is once fully established, it cannot, in the majority of cases, be cut short. Its "cure" must often consist in checking to the utmost possible degree its dangerous tendencies and sustaining the strength of the patient until the malady ceases by self-limitation.

The fact that diphtheritic inflammation is characterized by an extreme liability to be aggravated by any extraneous irritation, and that such aggravation of the inflammation inevitably involves the increase and intensification of the disease, forbids the use of all harsh measures that are not absolutely necessary, and requires the utmost possible gentleness in all manipulations and medication.

The fact that the tendency of the disease is to asthenia requires the careful avoidance of all unnecessarily weakening, harassing or fatiguing measures.

It follows that, especially in the treatment of young children, who constitute a large proportion of our patients in this disease, it is of the greatest importance to avoid all medication which is so unpleasant to the taste or so painful to the sensitive throat as to arouse repugnance and opposition, and thus occasion a series of exhausting struggles. Not a little treatment which has been excellent in intention and sound in principle, has been rendered futile or even worse than no treatment at all by having precisely this effect.

The application of this principle makes it necessary to omit some methods of treatment in the cases of young children, which are practicable and very valuable in those of older patients.

On the other hand, it is important to remember that the insidious and dangerous character of diphtheria demands the utmost promptitude and decision in combating it. Measures which are essentially unpleasant but necessary must be inflexibly carried out. Everything depends in many cases on the *earliness* with which efficient measures are employed.

While the theory of the treatment of diphtheria consists in the application of certain broad and easily understood principles, its successful practice requires the closest attention to details—many of them apparently trivial. This in all severe cases includes the necessity of very frequent visits on the part of the physician, and the careful instruction of parents and nurses.

The successful treatment of diphtheria not only demands a careful adaptation of measures to each particular case, but often especially requires a patient persistency in the use of well-selected ones. Under the best treatment there must often be a succession of anxious days in which little or no positively curative impression seems to be made upon the malady. Impatience, indecision, and changes of method without definite reason, are but too liable in the battle with this disease, as in other conflicts, to invite defeat.

THE RESULTS OF TREATMENT.

The test of the value of therapeutical measures is their results. Yet an accurate estimate of those results in the treatment of diphtheria is extremely difficult. This difficulty arises mainly from two causes:

1. The great differences in inherent tendency to a favorable or a fatal issue in different cases of diphtheria according to their type (as benign, severe or malignant), their localization (as laryngeal, nasal or pharyngeal), according as they are sporadic or epidemic, and according to the widely varying character of different epidemics. The records of mortality from the disease under the same or similar modes of treatment vary from this cause between the most remote extremes.

2. The confusing character of such records is greatly in-

creased by the frequency of errors in diagnosis. Dr. L. E. Holt[1] well says, "Our journals are continually filled with new specifics, accompanied with an enumeration of cases in which they have been successful. When detailed reports of cases are given, it is evident from a critical examination of them that the great number of them are not cases of diphtheria at all, while the universality of the successes claimed by others is a sufficient proof of the worthlessness of their observations. It must be evident to any one who attempts to keep up with the literature of the subject, that before any great advances can be made in the treatment of diphtheria we must insist on greater exactness in its diagnosis."

It may be conducive to a just estimate of the value of reports of therapeutical results in this disease to consider for a moment what results from treatment can rationally be expected. All cases of true diphtheria may be divided into three classes, namely (1), those which would recover without any medical treatment; (2), those which will terminate fatally under any treatment at present known, and (3), those the issue of which depends on the treatment employed. Any attempt to fix the proportion of these three classes must of course in the absence of data be in a large degree conjectural. I shall venture in this sense to estimate the first class at forty-five per cent. of all cases; the second at ten per cent., and the third again at forty-five per cent., though this last percentage is practically diminished and the second increased by the fact that in all large numbers of cases a considerable proportion come under the care of the physician too late for treatment to be effective. It is evident, even without assuming the accuracy of these estimates, that the distribution of these three classes, especially in small series of cases, may be so different that apparently very favorable or very unfavorable results of treatment may be largely accidental.

By the law of averages, the liability to this source of error is greatly diminished in large numbers of cases, but even such statistics are worthless if there is room for doubt as to the correctness of the diagnosis. It follows that all statistical contributions to the therapeutical literature of diphtheria, in order to be of authoritative value, should not only accurately describe the methods of treatment employed, but should also be accompanied with such descriptions of the cases referred to as will place it beyond doubt, not only that they were genuine cases of diphtheria, but also to what forms and types of the disease they belonged. By such painstaking methods only can the requisite data be furnished for a reliable system of therapeutics in this disease.

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[1] Trans. of the Med. Soc. of the State of New York, 1886, p. 553.

THE MODES OF EMPLOYING REMEDIES.

1. *Internal Administration.*—This is not only the usual method of employing remedies for constitutional effect, but is also one of the most important modes of their local application. For the latter purpose it has the advantages of simplicity and easy availability, and important and obvious limitations as to the class of medicinal agents to which it is adapted, and the surfaces which it reaches.

2. *Gargling.*—This method is not only unavailable in the cases of young children, but even in those of older patients its frequent employment in diphtheria is unpleasant and fatiguing. It is moreover in many cases inefficient, from the remedies so employed not freely reaching the posterior part of the pharynx. It is therefore in most cases inferior to the two methods next to be mentioned.

3. *Spraying.*—This method has the advantages of being gentle and unirritating, and not very fatiguing, and that by it remedies may be applied in a more direct, evenly diffused and continuous manner to the oral and pharyngeal surfaces than by most other methods, and may even by the aid of the inspired air be made to reach the rima glottidis and the vocal cords. It is important to remember that if the spray is too

coarse and too forcibly driven its effect may be irritating. This method is advantageous only when the fluids so used reach the affected surfaces *as spray*. It is efficient in the throat only when the mouth is widely opened or the tongue is depressed. Its frequent use, therefore, requires the voluntary coöperation of the patient, and is unfortunately not practicable in most cases of children under three years of age. For reasons which will be referred to in speaking of the treatment of nasal diphtheria, it is in most cases less available in that condition than the method next to be mentioned.

4. *Irrigation.*—This may be effected by means of a syringe, of the piston, hand-ball or fountain variety. The first is usually preferable. It is a very important and valuable method of cleansing affected surfaces and applying suitable remedies to them. It is, however, important that it be employed with the utmost gentleness which is consistent with its efficiency, as otherwise its effect may be irritating and injurious. Its special applicability is to the nasal passages, and to the throat in the cases of children too young to be sprayed.

5. *Vaporization and Inhalation.*—This method has obvious advantages for the introduction of certain substances into the system for constitutional effect, and also for bringing them into direct contact with the otherwise inaccessible mucous membranes of the air-passages. Its most important limitation is the danger of its interference with the purity or respirability of the air.

6. *Insufflation.*—The application of certain substances to directly accessible surfaces in the form of powder has obvious advantages. Substances so applied are liable to be irritating in direct proportion to their insolubility and the coarseness of the powder.

7. *Application by means of a brush, pencil, or swab.*—This method has the advantages of precision and accurate limitation. It is therefore specially adapted to the application of concentrated and irritating substances. Its use is contra-

indicated for other than directly accessible surfaces, and, as a general rule, in the cases of young children.

Various details in these modes of employing remedies will be more appropriately spoken of elsewhere.

CAUSTICS.

Aretæus advocated the employment of caustics in the following words: "Utile fuerit, igitur, partem affectam igne adurere, sed factu temerarium utpote in tam angusto faucium loco; quam ob rem medicamentis igni simillibus utendum est."[1]

Bretonneau obtained "favorable results" and "cures" by the local application of concentrated hydrochloric acid, either diluted with three parts of honey, or, later and preferably, pure, the object and effect being to "substitute another inflammation in order to arrest that which is specific." Recognizing the danger of harsh applications, Bretonneau limited its employment as follows: "When the disease is not arrested by two energetic applications made at an interval of twenty-four hours it would be imprudent not to abandon it."

The employment of nitrate of silver having been introduced by Dr. Mackenzie,[2] of Glasgow, Bretonneau, in his fifth memoir, stated that he had found it less painful and more efficacious than hydrochloric acid. He employed the solid stick and a sponge moistened with a strong solution. He stated that when the treatment is commenced on the first day of the disease (two applications being made daily) "a radical cure may be obtained in forty-eight hours," but that "every hour and every day the necessity of a more active and prolonged treatment goes on increasing in melancholy proportion."

That the practice of Bretonneau was attended with very favorable results is evident even from his modest statements. For instance, he mentions that on one occasion when he was summoned by the Minister of War to the *École Militaire*, on account of an epidemic of malignant angina which had shown an alarmingly fatal character, he treated sixty of the pupils who were suffering from the disease at a more or less advanced stage with a favorable result in every case.

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[1] It would be useful to burn the affected part with fire, but a rash practice on account of the narrowness of space in the fauces; for which reason medicaments similar to fire must be employed.

[2] Med and Surg. Journ., vol. xxiii., p. 294.

In laryngeal diphtheria the moistened sponge was applied to the glottis, the epiglottis being held up by a spatula. The result was that in some cases the false membrane was expectorated and the necessity for tracheotomy obviated, a cure resulting on the fifth or sixth day. Similar results in his own practice and in that of his fellow practitioners were reported by Mackenzie, of Glasgow, and also by Gendron,[1] Girouard,[2] Bouchut,[3] Velpeau,[4] Geddings,[5] and many others. Trousseau practiced and recommended cauterization with the substances just referred to, and also with cupric sulphate in saturated solution, and the acid nitrate of mercury. Other caustics which have been employed in the treatment of diphtheria are nitric, sulphuric, chromic and strong carbolic acid and caustic soda and potash. With the exception of carbolic acid, which may sometimes be advantageously used either pure or diluted with equal parts of glycerine or water, their action is both painful and dangerous.

The use of the actual cautery during an epidemic of diphtheria in 1828 by Dr. Bonsergent, who thrust a red-hot iron into the diphtheritic throats of children, is described by Trousseau,[6] who "witnessed some successful results" of this dangerous procedure. Trousseau employed it himself, but only in cutaneous and vulvar or oral diphtheria.

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[1] Journ. compl. du Diction. des Sc. Méd., t. xxiii., p. 346.
[2] Journ. Gén. de Méd., t. ciii., p. 305.
[3] "Traité pratique des Malad. des Nouveaux Nés," etc., 1852.
[4] Gaz. Méd., 1830, p. 11.
[5] Amer. Journ. of the Med. Sc., vol. xxiv.
[6] Clinical Medicine, vol. ii.

The use of caustics was in some cases attended with deplorable accidents and fatal results, which called forth protests against their employment from Archambault-Reverdy[1] and many subsequent writers. Moreover, the spread of the belief in the primarily constitutional rather than local nature of diphtheria contributed not a little to their gradual and almost universal disuse. The use of nitrate of silver has, however, always had its adherents. Dr. T. J. Hutton[2] of Fergus Falls, Minnesota, for instance, applies lunar caustic in solution in the strength of from twenty to fifty grains to the fluid drachm of water with a camel's hair brush once or twice daily so long as membrane continues to form. He states that in 209 cases thus treated by him only twelve have died.

Among the caustic agents which have been referred to, the nitrate of silver is least open to certain objections and has special limitations. Its action is comparatively superficial. It is one of the least irritating of caustics. Locally it causes greater contraction of the vessels than other metals. (Brunton.) It combines with albumen and destroys or imprisons parasitic fungi which are exposed to its action. Its utility as a caustic in diphtheria is therefore limited to the earlier stages and the more superficial forms of the disease.

The use of the actual cautery has been revived in the form of the galvano-cautery, by Dr. Tedeschi[3] and by Dr. Bloebaum.[4] This treatment was first employed by the latter in many cases of diphtheria in young pigeons and subsequently in a number of cases of human diphtheria. Besides gargles of ice-water no other treatment was employed. Prof. Henoch,[5] of Berlin, also employed this method in a grave case of diphtheria with a favorable result.

The use of the galvano-cautery is described as painless.

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[1] Journ. Univ. des. Sc. Méd., t. lvii., p. 257.

[2] New York Med. Rec., April 9, 1887, p. 417.

[3] Rivista Venet., Nov., 1885.

[4] Verhandl. d. Cong. f. innere Med., Wiesbaden, 1886, V. 432.

[5] Therapeutic Gazette, 1886, p. 603.

At its mere touch the false membrane rolls up and falls off. It is not reformed nor does the diphtheritic process extend. The fever and the glandular swelling rapidly subside. The slough which it causes comes away in eight to fourteen days, leaving a healthy ulcer.

Even after making all due allowance for mistakes in diagnosis and other sources of error, the evidence which has now been referred to seems to be conclusive to the effect that the application of caustics in the early stage of diphtheria has in not a few instances cut short the disease, preventing its local development and its constitutional manifestations. This fact is of great interest and importance as adding confirmation to the view of the primarily local nature of diphtheria which has been maintained in this work, and is full of suggestiveness as to the direction which should be given to future efforts to perfect the therapeutics of the disease, especially in its early stages. It cannot be denied that the application of powerful caustics in diphtheria is open to grave objections and is at best subject to great and important limitations. The theory of their use is the destruction of the specific character of the inflammation. It is evident, however, that if they fail to completely accomplish this object, the inflamed and necrosed tissues caused by their use must become an especially favorable soil for the occupation of the diphtheritic virus, and the result is liable to be an aggravation of the disease. Since the utility of cauterization is mainly restricted to the early stage of the disease, and to cases in which it is definitely limited to easily accessible locations, its employment is under any circumstances practically excluded in a large proportion of the worst cases with which we have to deal. Since, moreover, it is liable to be more or less painful, is in its very nature calculated to inspire dread, is difficult or impossible of safe execution in the cases of young children, and, moreover, when employed injudiciously or clumsily is liable to produce disastrous results, it is not probable that the verdict of the profession, which has consigned it to almost complete disuse, will ever be to any great extent reversed. Other and less hazardous means of accomplishing the same ends will continue to be sought for.

ASTRINGENTS.

Astringents are especially valuable in the presence of great swelling of the tonsils and uvula, relaxed, ulcerated or hæmorrhagic conditions of the mucous membrane and profuse secretions.

The astringents which have been principally employed in the treatment of diphtheria are alum, tannin, the liquor ferri subsulphatis and the chloride of iron.

The use of alum and of tannin (in the form of powdered nut-galls) was recommended by Aretæus. The former was used by Bretonneau, and both by Trousseau. Powdered alum has been much used by being blown into the throat through a tube or by means of an insufflator. Trousseau employed in this way from one to two grammes at each application, which he caused to be repeated from four to ten times in the twenty-four hours. He advised that these be alternated with insufflations of four or five grains of tannin. Alum mixed with honey and the glycerine of tannin have also been applied with a camel's hair pencil. Alum in solution in water or in vinegar and water has been beneficially employed by gargling and irrigation, and tannin in a five per cent. watery solution as spray.

The liquor ferri subsulphatis (Monsel's solution) has been found by many to be an especially valuable local astringent. It may be applied either pure or diluted with an equal part of water or glycerine by means of a camel's hair pencil or a fine soft swab to easily accessible diphtheritic patches once or twice daily. Its effects are thus graphically described by Dr. C. C. P. Clark,[1] who has for twenty years used no other local application: The salt is in no way a caustic, nor, so far as he knows, a poison to bacilli, "but it is a mighty astringent, and seems to operate by puckering the life out of the diphtheritic deposit and sucking or squeezing the bad juice out of the living parts adjacent. The patch or patches may indeed reappear again and again, but always with less density and diminished rankness of look."

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[1] New York Med. Journ., June 7, 1884.

Dr. J. Solis-Cohen[1] has found chloride of iron applied locally by firm and gentle pressure with a brush, or, preferably, cotton-wad—the most serviceable agent he has used in topical treatment. "The drug has an astringent and antiseptic action, assists the detachment of false membrane, and apparently prevents the spread of the infection."

From the occasional topical use of both of the drugs last referred to, either pure or diluted with half the quantity of glycerine, I can testify to their favorable action in suitable cases.

Agents for the Destruction of False Membrane.

False membrane may be removed by the use of escharotics (which has already been spoken of), by avulsion and by solvents. From considerations which have been already referred to as to the evil of harsh and irritating measures in the treatment of diphtheria, it is now a well-recognized principle that as a general rule the forcible removal of diphtheritic membrane is a procedure which is to be mentioned only to be condemned. When a portion of a membranous patch has become detached and loosened, while a deeper portion still continues adherent, there is great temptation to the inexperienced physician to hasten the cure by its removal. But not only should this temptation be resisted, but especial gentleness in the giving of food and medicines should then be practiced, since its premature detachment is very liable to be followed by an intensification of the inflammation, increased absorption of poison and a new formation of membrane.

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[1] Medical News, June 23, 1888.

Loosened portions of still adherent membranous patches may, when accessible, be advantageously trimmed away with scissors.

The removal of membrane by scraping, rubbing or picking it away with forceps has been employed by some in the early stage of the disease as a preliminary to the local application of an antiseptic, as will subsequently be more particularly referred to. The capabilities and limitations of such methods are so nearly identical with those of the use of caustics that they need not be further referred to.

SOLVENTS OF FALSE MEMBRANE.

Warm vapor has long been much employed for softening, disintegrating and promoting the detachment of false membrane. Dr. M. J. Oertel,[1] advocates the general use of this agent in the treatment of diphtheria, and that the inhalations be practiced as often and as long as possible—for fifteen minutes every half-hour on the first and second day, allowing only three or four hours for sleep.

The softening and loosening of the false membrane is effected not merely by the action of the vapor upon it, but also by the increased secretion of mucus and the promotion of suppuration beneath it.

There can be no doubt of the tendency of warm vapor to produce all of these effects, and that it is a valuable therapeutical agent whenever the false membrane lies loosely and superficially upon the mucous membrane, as it usually does in the larynx, the trachea and the bronchial tubes. In the pharynx, where the false membrane is commonly more deeply imbedded and more firmly attached, the employment of this mode of treatment is open to serious objections. Then the time required for the softening and loosening effect of the steam is necessarily much greater, and meanwhile not only is the false membrane softened, but the healthy tissue also is macerated and relaxed—a condition which, while it promotes suppuration, probably favors also the penetration of pathogenic fungi and the absorption of septic poison. The tendency of the use of steam to produce this effect was pointed out by Dr. A. Jacobi in 1874. Its actual observation in a number of cases has long ago led me to regard the valuable application of this therapeutical method as mainly limited to the treatment of croup.

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[1] Ziemssen's Cyclopædia, vol. i.

The effect of steam upon false membranes may be increased by making it the vehicle of other solvents. This is often done by slaking lime in the croup-kettle or other receptacle, or by placing lime-water or other solvent solution in the cup of the steam-atomizer. It should be remembered that the vapor produced by boiling lime-water is simply—steam.

Medicinal agents which are capable of dissolving false membrane without exerting any injurious effect upon the living tissues have long been eagerly sought for, and some of them hold an important place in the therapeutics of diphtheria.

The principal substances which have been thus employed are lactic acid, lime-water and other alkalies, pepsin, trypsin and papayotin.

The inferiority in solvent power of lactic acid to lime-water or trypsin has been shown in the following experiment by Dr. F. E. Waxham.[2] Three similar pieces of false membrane were sprayed at half-hour intervals, one with a solution of trypsin, the second with officinal lime-water, the third with a ten per cent. solution of lactic acid. The first was dissolved in two hours; the second, in three hours; the third was softened, but not completely disintegrated, in three and one half hours.

In rapidity of action as a solvent of membrane, lime-water is probably inferior to trypsin. This inferiority is illustrated in the following experiment by Dr. H. D. Chapin:[3] Two pieces

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[1] The American Journal of Obstetrics, February, 1875.
[2] Chicago Med. Journ. and Examiner, June, 1885.
[3] New York Med. Record, March 7, 1885, p. 257.

of very thick firm membrane *in situ* on two portions of the trachea, which had been bisected post-mortem, were sprayed every fifteen minutes, the one with a solution of trypsin, the other with lime-water, to which one per cent. of liquor potassæ had been added. In two and one half hours the former was completely diffluent, except the under side of its thickest portion, which retained some membranous structure; the latter was softened but its integrity was preserved.

Lime-water in therapeutical use where rapid solvent effect is required is inadequate. It may be sprayed day after day upon diphtheritic membrane in the throat with the effect only of dissolving away the thinner portions and superficially softening and thinning the thicker portions. Its principal utility as a solvent in the case of thick and dense membrane therefore consists in rendering it more permeable by antiseptic agents through osmotic action, and thus giving important aid in disinfection. While it is not available against the more severe forms of laryngeal diphtheria, it is of great value in many cases in which the membrane is not very thick. In quite a number of such cases I have seen it keep the affection within such moderate bounds that recovery has taken place without the necessity of an operation.

It has been theoretically urged against the efficiency of lime-water spray as a solvent of false membrane in the throat that it must at once be rendered inert by the carbonic acid in the expired breath. That this supposition is erroneous I have shown by experiments with pieces of litmus paper held in the back part of the pharyx.[1] The same fact has also been shown by Dr. J. Lewis Smith,[2] who found by experiment that mixing lime-water with one-fourth its quantity of carbonic-acid water "did not seem to impair materially the solvent power of the lime."

In estimating the therapeutical value of lime-water in diphtheria it is important to remember that, aside from its solvent action upon false membrane, its other effects, even when it is used continuously, are in no way injurious, but are in every respect eminently calculated to be beneficial. It is a mild astringent, a mild antiseptic (destroying bacterial spores in ten days (Koch), a local sedative and antiphlogistic. Its very valuable sedative and corrective action in the irritable stomach is well known. Hence its utility is much more likely to be underestimated than overrated. From much experience in its use I regard it as entitled to a place in the very front rank of remedial agents in the treatment of diphtheria. Lime-water may be employed by internal administration, by irrigation, and as spray, either pure or in combination with other antiseptics.

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[1] See New York Med. Record, 1880, xvii., p. 383.

[2] Op. cit., p. 322.

Other alkalies, such as liquor potassæ or bicarbonate of soda, have been added to lime-water for the purpose of increasing its solvent power. Such addition of one per cent. of the former is recommended by Dr. J. Lewis Smith; and bicarbonate of soda has been employed in solution and by insufflation.[1] As either of these alkalies is known to be slightly irritating to inflamed mucous membranes, their availability for very frequent and continued application must be inferior to that of lime-water, though they may be very valuable in emergencies requiring rapid solvent effect.

Pepsin acts efficiently only in an acid solution—one containing from one to two tenths of one per cent. of hydrochloric acid being the most favorable. The fluids of the mouth and throat are usually either alkaline or neutral. This has been regarded as an important drawback to the availability of pepsin as a solvent of false membrane *in situ*, and it has of late been to a great extent superseded in general use for this purpose by trypsin and papayotin.

In a paper recently read before the Section on Pædiatrics of the New York Academy of Medicine[1] Prof. R. H. Chittenden made the following important statements: Even making allowance for the disadvantage just referred to, pepsin must at present be regarded as a more reliable solvent of false membrane than trypsin—not that trypsin is a less efficient solvent, but that, owing to the great difficulty of isolating it, no trypsin has yet been produced which is nearly as powerful as the best pepsins which are now in the market, though the trypsin produced by Fairchild has considerable efficiency. The difficulty arising from the alkalinity of the fluids in the mouth and throat may be obviated in the following manner: The amount of hydrochloric acid in the pepsin solution should be a little in excess of that required for normal digestion—say about four tenths of one per cent., in order to allow for its neutralization and dilution. The solution employed should be a concentrated one, and the applications should be very frequent. A suitable mode of employing it would therefore be by the following formula:

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[1] Dr. E. M. Moore, Transactions of the N. Y. State Medical Association, 1885.

℞	Scale pepsin, ...	℈j—ʒss.
	Acidi hydrochlorici, . . .	♏ij.
	Glycerini, ...	ʒj
	Aquæ dest., ...	ʒvij.
	M.	

To be applied every five, ten, or fifteen minutes by brush or atomizer.

There is abundant testimony to the quite rapid solvent action of trypsin upon diphtheritic membrane. Dr. H. D. Chapin[2] describes a case in which extreme symptoms of tracheo-bronchial diphtheria which gradually supervened after tracheotomy were mitigated within half an hour and entirely dispelled in a few hours as the result of frequent spraying through the cannula with a solution of trypsin. The child having died of blood-poisoning, the autopsy showed thick membrane lining the larynx and trachea down to the spot that was first reached by the spray; but below that point there were on the intensely injected mucous membrane only disintegrated shreds of false membrane, which condition continued as far as to the bronchial tubes of the second order.

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[1] Medical News, 1889, vol. liv., p. 173.

[2] Loc. cit

Since the first effect of the application of a pepsin-acid solution is to cause the swelling up of false membrane, while trypsin produces its direct disintegration, the latter should be preferred for spraying into the larynx in diphtheritic croup.

Trypsin acts best in an alkaline medium, and its solvent action is undoubtedly aided by that of the alkali. The following is a suitable mixture, which should be freshly prepared when it is to be used:

℞ Trypsin, ...	ʒ ss.
Sodæ bicarbonatis, ...	gr. x.
Glycerini, ...	ʒ ss.
Aquæ destillatæ, ...	ad ℥ j.

To make a smooth mixture the trypsin should be rubbed down with the water added little by little. When it is used with a brush a little should be poured out in a saucer for the purpose, in order to avoid returning the brush into the solution after using it. When it is used in spray the best method is to fit the atomizing instrument to a small narrow bottle or a test-tube, into which a drachm or two of the mixture may be poured. This may now be immersed in a glass of hot water until its contents are warm, and then the spray may be applied. Trypsin acts more rapidly when at a temperature slightly above that of the body. The remainder of the mixture should be kept in a well-stopped bottle. These directions accompany the trypsin of Fairchild, which has been referred to as being especially efficient. Trypsin should be applied very frequently—every ten or fifteen minutes being not too often.

Papayotin is efficient in an alkaline or a neutral medium, and less so when the reaction is acid.

Neither of the solvents last referred to has any specific action upon false membrane, but they are simply ferments which act with great power in dissolving coagulated albumen.

Papayotin has usually been employed in a five per cent. solution in water, sometimes with the addition of an antiseptic, as a small proportion of salicylic acid, applied hourly or half-hourly, by brush, irrigation or spray. Dr. A. Jacobi[1] recommends its use in the proportions, papayotin one part, glycerine and water, each two to four parts, applied hourly. Rossbach[2] says that in order to be most effective the solution should be applied to the parts every five minutes, a few drops being placed upon the tongue or in the nose. Very young children may be allowed to suck a napkin which is moistened with a sweetened solution, or it may be inhaled after atomization. By this plan the membrane often becomes dissolved in two or three hours. He believes that if this substance is properly used it will obviate the necessity for tracheotomy. There is a general concurrence of testimony in respect to both papayotin and trypsin, that though they do in some cases at least, especially in the early stage of diphtheria, exert a favorable and limiting effect upon its course, yet they are not specifics for the disease, that they are without curative effect upon its infiltrated form, and that the constitutional disease when once established may go on to a fatal termination in spite of the dissolution of the false membrane.

There is also a general agreement that both of these agents are innocuous to mucous membranes.

The following is a suitable formula for the use of papayotin:

℞	Papayotin,	gr. xxv.
	Glycerini,	ʒ ss.
	Aquæ destillatæ,	ad ℥ j.
	M.	

The powerful tendency of jaborandi and pilocarpine to increase the secretion of mucous membranes has led to their administration for the purpose of thus causing the maceration of diphtheritic membranes, and hastening their detachment. Its successful use in many cases has been reported by G. Guttmann[1] and others. Lax[2] recommends the following formula

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[1] Therapeutic Gazette, 1886, 145.

[2] Deutsches Arch. f. Klin. Med., Bd. XXXVI., H. 3 and 4.

℞	Pilocarpini hydrochlorat.,	gr. iij.
	Pepsinæ,	gr. j..
	Aquæ dest.,	fl. ℥ ij ʒ iss.
	Acidi hydrochlorici,	gtt. ij.
	M.	

Dose, a small or large spoonful to be given according to age and effect.

Since pilocarpine is liable to cause depression of the heart's action, collapse, nausea and vomiting and albuminuria, and since the copious salivation and perspiration which it produces are necessarily weakening, its continued use for a long enough time to fufill the above-mentioned indication is now generally condemned as dangerous.

ANTISEPTICS.

CLEANLINESS.

In the "Instructions for Disinfection" by the New York Board of Health, from which quotation has been made in the preceding chapter, it is well remarked that "disinfectants" (*i.e.* chemical agents) "should not be relied upon to correct conditions due to dirt, decomposition, defective ventilation and neglect." This principle, so true in reference to the disinfection of apartments, premises, etc., is equally applicable to the disinfection of the living body in the treatment of diphtheria. The thorough cleansing by suitable means of all surfaces affected by the disease, or liable to become so, in the mouth, the throat, the nasal passages and elsewhere, is of far greater practical importance in the whole number of cases than the mere administration of antiseptic drugs, and the use of the latter, though important, can in no case atone for neglect or inefficiency in the former.

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[1] Berlin. Klin. Wochenschr., 1880, No. 40, p. 569.

[2] Journal de Medécine de Paris, Feb. 6, 1887.

THE RESISTANCE OF THE ORGANISM.

Bacteria and their spores, which invade the blood and tissues, are attacked, digested, and destroyed by the cells,[1] or in case of their overwhelming number and vigor destroy the cells. When the body is weak or exhausted by hunger or fatigue the power of thus destroying invading organisms is proportionally small. From this fact it appears that nutritive and sustaining measures in the treatment of infectious diseases may properly be regarded as measures of disinfection, that the use of antiseptic drugs which may be weakening to the patient should be carefully avoided, and that an agent which merely diminishes in a slight degree the vital activity of bacteria may turn the scale in the conflict between them and the cells, provided that it is less poisonous to the latter than to the former.

THE SALTS OF MERCURY.

Among bactericidal drugs, the one which is efficient in the greatest dilution is the bichloride of mercury. According to the experiments of Koch[2] it hinders the development of anthrax bacilli (a comparatively resistant organism) in the strength of $\frac{1}{1000000}$ in the nutrient solution, prevents it in the strength of $\frac{1}{333333}$, kills the spores of the bacilli in ten minutes in the strength of $\frac{1}{20000}$, and with one wetting in the strength of $\frac{1}{1000}$.

Other salts of mercury, as the sulphate, the nitrate, the cyanide and the iodides are also very efficient bactericides, though in a somewhat less degree than the bichloride.

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[1] Metschnikoff, Virch. Archiv. vol. xcvi., p. 177, and xcvii., p. 502, and Fodor, Arch. f. Hygiene, Bd. 134, p. 149.

[2] Mittheilungen aus dem k. Gesundheitsante, vol. i.

For prompt and certain local antiseptic effect corrosive sublimate is applied in a solution of the strength of from $\frac{1}{1000}$ to $\frac{1}{500}$ by brush, swab or atomizer.

In order that this effect shall be produced it is necessary that the bacteria and their spores be actually wetted with the solution in its full strength or nearly so. If the affected surfaces are covered with profuse and viscid secretions, as is often the case, they should first be cleansed by spraying or irrigation, and afterwards dried by touching them lightly with absorbent cotton.

A still greater obstacle is usually presented in the false membrane. If this be exceptionally thin, superficial, and loose of texture, the solution may penetrate to its under surface with no very great dilution; but in proportion as it is thicker and denser this becomes impossible.

But even if the false membrane have previously been removed, the fact remains that the fungi of the disease, so far as we have means of judging, do not lie merely on the surface of the mucous membrane or the denuded tissues, except at a very early stage of the disease or in its more superficial forms, but also beneath the epithelial layers or even in still deeper structures.

It follows from these considerations that the eradication of diphtheria in its really deeper and graver forms, except at a very early stage, even by the local use of this most powerful of bactericides must often be opposed by insuperable obstacles, and this conclusion is confirmed by experience. For example, W. W. Cheyne[1] has employed the following treatment: He first removes as much of the membrane as is possible with forceps, and then applies to the denuded surface a watery solution of bichloride (one in five hundred) with a brush every two hours, especial attention being directed to the margin of the affected region. In the intervals a gargle of bichloride in the strength of one two-thousandth is used. This treatment has

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[1] British Medical Journal, March 5, 1887, p. 504.

"quickly and completely arrested" the disease in several adult cases which were "taken early," but in the case of children "the results are not so good."

Corrosive sublimate is also employed in higher dilution—that of $\frac{1}{3000}$, $\frac{1}{5000}$ or $\frac{1}{10.000}$—for local antiseptic effect by frequent internal administration, gargling, irrigation and atomization. That a solution of one grain of corrosive sublimate in the pint of water is a safe and useful antiseptic wash in many cases of diphtheria cannot be doubted; yet even in that dilution the effect of its frequent application to diphtheritically inflamed surfaces has seemed to me less beneficial and more liable to be irritating than that of other substances yet to be mentioned. It should also be borne in mind that in spraying the throat and irrigating the nasal passages of children, even with a solution of this strength, caution is needed that a dangerous quantity of the poisonous salt be not swallowed.

In view of the enormous dilution in which corrosive sublimate diminishes the vital activity of bacteria, the idea that it may be introduced into the circulation in sufficient quantity, even making allowance for its constant elimination, to have some influence in the struggle between the living body and its pathogenic invaders is probably not altogether chimerical. This view is favored by the results of the experiments of Cash,[1] who found that the continued administration of minute doses of sublimate to animals rendered them capable of resisting the effects of the subsequent inoculation of anthrax.

There is reason to believe that the salts of mercury, internally administered, have a tendency to oppose the occurrence of fibrinous exudation in the air-passages, and to promote its detachment when formed. Reports of the successful treatment of membranous croup with calomel have been too numerous in the medical literature of this and other countries to be easily explained by the theory of mere coincidence. Though that treatment, having been found in many cases disappointing in its result and injurious in its effects, was long ago generally abandoned, yet testimony to its efficacy continues occasionally to appear. Heroic dosage is an element in its employment by some, as for instance in the successful treatment of three children suffering from laryngeal diphtheria, twenty grains of calomel was given at first, followed by ten grains hourly—seven hundred and twenty grains having been taken by a child twenty-eight months old in three days![1]

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[1] Proceedings of the Physiological Society, Dec. 12, 1885. Journal of Physiology, vol. vii.

It is a relief to learn that diphtheria has been successfully treated by the use of two to five grains of calomel every one to three hours until the dejections are frequent and green, then continuing the same doses at lengthened intervals so as to keep up the catharsis,[2] and even by doses of one sixth of a grain every hour, increased in the presence of threatening laryngeal symptoms to one third of a grain every hour, and then to one grain every two hours for five hours, in a patient eighteen months old,[3] and in thirty-six consecutive cases by the following method: The diseased part is first wetted with a two to five per cent. solution of common salt—then two to four tenths of a grain of calomel are blown over it twice daily, the throat being in the mean time gargled every two hours with the salt solution. A portion of the calomel becomes bichloride, and the remainder passes into the stomach and produces free catharsis.[4]

There is a concurrence of testimony from many judicious practitioners as to the benefit which may be derived from purgative doses of calomel at the early stage of diphtheria, especially in cases in which there is high fever with deficient secretions and marked nervous disturbance—a benefit which

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[1] Dr. J. P. Klingensmith, of Blairsville, Pa., New York Medical Record, July 12, 1884, p. 36.

[2] Dr. W. H. Daly, of Pittsburg, New York Med. Record, June 12, 1886, p. 692.

[3] Dr. Geo. B. Fowler, New York Med. Record, Nov. 19, 1887, p. 647.

[4] Kotzuski, Jahrb. f. Kinderh., xxi., p. 272.

I have observed in many cases, and which was referred to in my first publication (1876). It may be given in a single dose of from two to ten grains, or in doses of a fraction of a grain (one tenth to one half) repeated frequently (from every twenty minutes to every two hours) until its characteristic purgative effect is produced.

At the present time mercury is most generally employed in the treatment of diphtheria in the form of the bichloride. Its use in large doses (one quarter to one-half grain or more daily) has been advocated in this country by Dr. W. Pepper,[1] (and hence widely known as the "Pepper treatment") and subsequently by Dr. A. Jacobi [2] and by many others.

Of its efficacy in diphtheritic croup, Dr. Jacobi [3] says, "I have never since 1863 seen so many cases of tracheotomy getting well as between 1882 and 1886, when the bichloride was constantly used as mentioned. . . . . I can name a dozen of New York physicians, some of whom have often performed tracheotomy, who can confirm the above statements from their own observations. Nor does the opinion of those differ who constantly perform intubation. I know that O'Dwyer, Dillon Brown and Huber have come to the same conclusions." The doses referred to by Dr. Jacobi are "from one sixtieth to one fortieth of a grain and sometimes more," given hourly in a tablespoonful of water, milk or other compatible fluid.

To the valuable efficacy of the bichloride of mercury (as, indeed, of most other prominent remedies used in the treatment of diphtheria) there is in recent literature a striking array of testimony, of which the following examples are given mainly to illustrate different modes of employing it:

Dr. E. C. Carter, Assistant Surgeon United States Army,[4] in an epidemic of diphtheria near Fort Thomas, Arizona, having treated the first eleven cases with other remedies with four fatal results, gave bichloride in thirty-four subsequent cases in doses varying from one sixty-second to one twenty-fourth of a grain with unvarying success. That they were genuine cases of diphtheria seems to be attested by the fact stated that twelve of the patients who recovered had paralysis.

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[1] Transactions of the American Medical Association, 1881.

[2] "The Medicinal, mainly Mercurial, Treatment of Pseudo-Membranous Croup," New York Medical Record, 1884, vol. 25, p. 573; and "A System of Medicine by American Authors," Phila., 1885, p. 705.

[3] "Therapeutics of Diphtheria," Medical News, June 16, 1888, p. 663.

[4] Medical News, Nov. 27, 1886, p. 593.

Dr. P. Werner,[1] having previously lost between sixty and seventy per cent. of ninety cases, employed bichloride treatment in the succeeding seventeen—mostly severe ones—with only two fatal results, and those in cases seen only a few hours before death. He gave doses of $\frac{1}{250}$ to $\frac{1}{85}$ of a grain (according to age), well diluted in water, every twenty or thirty minutes while the patients were awake, so that one quarter of a grain was taken daily by young children, one half by older ones, and three quarters by adults.

J. Stumpf,[2] having in the early part of an epidemic lost twenty-two out of twenty-nine cases, employed in the succeeding thirty-one cases the bichloride of mercury only, with favorable result in all but two. He administered in spray one fluid drachm of a solution of the strength of $\frac{1}{4000}$, $\frac{1}{2000}$ or $\frac{1}{1000}$ (according to age) hourly for five times, then every two hours for five times, and subsequently every three hours.

Dr. E. L. Oatman,[3] of Nyack, N. Y., having previously lost ten out of twenty-three cases under treatment with iron in large doses and free stimulation, has, since the addition of local treatment with the bichloride, lost only one out of thirty-four cases. Dr. Oatman prepares a number of swabs by firmly twisting absorbent cotton around the end of a small stick. Every hour one of these is dipped into a solution of the bichloride (two grains to the pint) and passed into the throat until it touches the posterior wall of the pharynx and then instantly withdrawn and burnt, no swab being used a second time. More or less of the membrane always adheres to the swab. This procedure is repeated hourly until the disease begins to subside, which it usually does in forty-eight hours. If the nares are affected, the nose is syringed.

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[1] St. Petersburg Med. Wochenschr., 1886, r. F. III., p. 81.

[2] Muenchener Med. Wochenschr., 1887, p. 219.

[3] New York Med. Record, April 23, 1887, p. 465.

The biniodide of mercury is regarded as especially efficacious by some. It is employed by Dr. C. G. Rothe,[1] of Altenburg, in the following formula:

℞	Hydrargyri biniodidi, . .	gr. $\frac{1}{4}$.
	Potassii iodidi, ...	gr. iij—gr. ivss.
	Aquæ destillatæ, . . .	fl. ℥ j ʒ vij.
	Tincturæ aconiti, . . .	♏ xv.
	M.	

A teaspoonful is given hourly to a child under three years of age. Dr. Rothe has thus treated successfully forty cases.

Extraordinarily favorable results from the use of the cyanide of mercury are reported by Dr. J. Bree[2] and by Dr. H.Selldén,[3] a Swedish provincial medical officer. The latter reports fourteen hundred cases treated by himself and his colleagues, with a total mortality of sixty-nine, or 4.9 per cent. The formula he recommends is as follows: Cyanide of mercury, two centigrammes (gr. $\frac{1}{3}$); tincture of aconite, two grammes (♏ xxx.); honey, fifty grammes (℥ j. ʒ ivss.); distilled water one hundred and fifty grammes (℥ iv. ʒ vss.). Mix and give a teaspoonful every fifteen, thirty or sixty minutes, according to the patient's age. A gargle of the cyanide in peppermint water in the strength of $\frac{1}{10,000}$ is also to be used frequently.

Inunction of mercurial ointment has also been much employed in the treatment of diphtheria. For its more rapid absorption the oleate is recommended by Dr. A. Jacobi[1]—ten or twelve drops to be rubbed into the skin every hour or two. The hypodermic injection of corrosive sublimate is recommended by the same author—four or five drops of a one-half or one per cent. solution to be so used from four to six times a day or more. Dr. F. P. Henry[2] states that the hypodermatic injection of corrosive sublimate is so painful that few will consent to its repetition, and prefers the bicyanide of mercury, since it is compatible with cocaine, which the former is not. He has found its employment in many cases by the following formula comparatively painless:

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[1] Journ. de Méd., June 5, 1887.

[2] "Behandlung der Diphtherie mit Quecksilbercyan," Dissertation, Berlin, 1886.

[3] London Lancet, March 24, 1888, p. 591.

℞	Hydrarg. bicyanid.,	gr. ij.
	Cocain. hydrochlorat.,	gr. iv.
	Aquæ destillat.,	fl. ℥ ss.
	M.	

Fifteen minims to be injected beneath the skin in the case of an adult.

Mercury by fumigation has been used in the treatment of diphtheritic croup with remarkable success by Dr. J. Corbin,[3] of Brooklyn. The child is placed in a crib under a tent prepared with barrel-hoops and blankets. Calomel is volatilized in the tent by heat, from forty to sixty grains being used in the case of a child eight or ten years of age. The lamp should be powerful enough to volatilize a drachm of calomel in one minute in order to avoid overheating the air in the tent. The child is kept under the canopy for twenty minutes, when the blanket is removed. This is repeated every two or three hours during the first day. After that period the cough is usually loosened, and the intervals between the fumigations are lengthened, but they should be at once resumed if the cough tightens. In some cases two or three fumigations daily have been continued for over a week. The aphonia may not disappear for a week or more, but that need excite no alarm. This treatment is not a substitute for tracheotomy or intubation.

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[1] A System of Practical Medicine by American Authors, vol. i., p. 705.

[2] Medical News, Nov. 3, 1888.

[3] New York Medical Journal, March 10, 1888, p. 261.

Including sixteen cases thus treated by himself, and fourteen by three other physicians, Dr. Corbin reports thirty cases, of which twenty-five, or about 84 per cent., recovered. In one of the fatal cases the treatment was abandoned by the family. In none of the other four did death result from obstruction of respiration, but from the effects of toxæmia.

The valuable action of mercury in the treatment of diphtheria, like that of most other remedies, is greatest when it is employed at an early stage of the disease. Then it has a tendency (in some cases at least) to limit the extension and moderate the intensity of the affection, and thus to diminish the subsequent constitutional poisoning. But when the septic condition is once established it has not the power to arrest it, but if excessively or too long used is very liable to aggravate it.

In the internal administration of the salts of mercury it is most important to remember that these valuable therapeutical agents, when used beyond certain limits as to frequency, quantity and continuance, are dangerous irritant and depressing poisons; that this action of them must be especially deleterious in a disease which is in itself so depressing as diphtheria, and is particularly liable to be overlooked from being attributed to the disease.

In a judicious and timely protest against the abuse of mercurials in the treatment of diphtheria, Dr. J. E. Winters[1] says, "I know that as the result of the inconsiderate use of mercurials in the treatment of diphtheria, physicians are often called upon to treat the consequences of their want of caution; while they have blindly ascribed the rapidly progressive anæmia, prostration, marasmus and death to the disease alone. . . .

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[1] "Diphtheria and its Management," New York Medical Record, Dec. 5, 1885, p. 617.

"I have unequivocal and direct evidence of the injurious effects of bichloride of mercury from two intelligent physicians who have had diphtheria, and who both experienced the depressing effect of the drug. They told me that they felt depressed as soon as the mercurial began to have an appreciable action on the intestinal tract, and that there was a feeling of nausea and sinking even preceding this. I may add that after the discontinuance of the bichloride both patients felt within three hours the strengthening effect of the tincture of iron in full doses given hourly."

CARBOLIC ACID.

Carbolic acid is a far less powerful bactericide than corrosive sublimate. An aqueous solution of it in a strength of $\frac{1}{1250}$ hinders the growth of anthrax bacilli: $\frac{1}{850}$ prevents it; $\frac{1}{500}$ to $\frac{1}{400}$ prevents the growth of other bacteria; a five per cent. solution requires more than twenty-four hours to kill the spores of anthrax bacilli, though a one per cent. solution destroys the bacilli themselves in ten minutes. Its use in full strength or with slight dilution as a caustic has already been referred to (page 158).

Carbolic acid has great utility in the local treatment of diphtheria, since in suitable dilution it is not only an efficient antiseptic but also has a valuable sedative and antiphlogistic action. Dr. T. M. Prudden[1] has shown that a solution of carbolic acid of the strength of $\frac{1}{1600}$, locally applied under conditions in which inflammatory changes commonly occur, modifies those changes by preventing any considerable emigration or locomotion of white blood-cells.

SALICYLIC ACID.

Salicylic acid is an efficient antiseptic. It hinders the growth of bacteria in a solution of the strength of $\frac{1}{3300}$; prevents it in that of $\frac{1}{1500}$; and kills bacteria in that of $\frac{1}{60}$. Successful results have been claimed from its use in powder by insufflation and by brushing it over the parts affected.[1] The following formula for its use is recommended by M. Ory:[2]

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[1] American Journal of the Medical Sciences, Jan., 1881, p. 82.

℞	Acidi salicylici, . . .	gr. v.
	Glycerini, ...	fl. ʒ iij.
	Aquæ lauro-cerasi, ...	♏ xvi.
	Infus. eucalypti, ...	fl. ℥ iijss.
	M.	

To be applied by brush every hour by day and every two or three hours at night. It is said to hasten the disappearance of false membrane.

Salicylic acid is more irritating to inflamed surfaces than carbolic acid. According to the statistics of Schüler,[3] in 41 cases treated with chlorate of potassium there were 6 deaths; in 23 cases treated with carbolic acid there was 1 death; in 15 cases treated with salicylic acid there were 7 deaths.

Dr. A. d'Espine[4] has ascertained by experiments that salicylic acid, even in a solution of 1:2000, is an excellent parasiticide of the bacillus of diphtheria. Its harmlessness in this dilution makes it a very available application by irrigations, which should be repeated hourly. The especial utility of this employment of it would obviously be in the early stage of the disease and as a prophylactic.

CHINOLINE.

Chinoline is a powerful antiseptic, and in strong concentrations is sharply caustic. Its local effect in the treatment of diphtheria has been favorably reported upon by Dr. O.

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[1] Noeldechen of Pforta, Deutsche Med. Zeitung, Nos. 33-36, 1886.

[2] Revue Gén. de Clinique et de Thérapeutique, July 5, 1888.

[3] Berlin Klin. Woch., 40.

[4] Medical News, 1889, 54, p. 187, from Revue Médicale de la Suisse Romande, Jan. 20, 1889.

Seifert[1] and others. Dr. Seifert used it in a five per cent. solution in equal parts of alcohol and water applied by brushing from twice daily to every three hours, and as a gargle in the following solution: chinoline 1.0 (15 grains); water, 500 (1 pint); alcohol 50. (1½ ounces); oil of peppermint, two drops. Prof. Ahlfeld,[2] however, in one hundred and ten cases of children treated by this method, reported a mortality of 28 per cent., and Dr. Lunin under similar treatment lost fifteen of twenty-eight patients.

RESORCINE.

Resorcine is also a powerful antiseptic, and is less caustic than carbolic acid. It has been employed by Liblond[3] in solution in glycerine (one in ten to fifteen parts) applied locally every two hours with favorable results, and like results from a similar use of it have been reported by Fraigniaud,[4] and H. Callias.[5] The latter employed a five to ten per cent. solution in water with a little glycerine by pencilling hourly, and a two per cent. solution every two hours by spraying. On the other hand Dr. Lunin lost nineteen of twenty-nine patients treated with resorcine.

SULPHUR.

Sulphur has long been much employed in the treatment of diphtheria, mainly by insufflation, and its effects have been lauded by many. When thus used a portion of it is changed into sulphurous acid or sulphuretted hydrogen, both of which are powerful bactericides. Insufflation is a difficult procedure in the cases of young children, and the remedy itself is unpleasant. Dr. H. V. Knaggs, of London,[6] recommends the following preparation as palatable and readily taken by children:

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[1] Jahrb. f. Kinderh., 1884, p. 462.

[2] Jahrb. f. Kinderh., 1884, p. 463.

[3] Journ. de Méd. de Paris, Dec. 20, 1884.

[4] Union Médicale, 1885, p. 493.

[5] Quoted by Le Gendre, Archiv. de Laryngol., No. 1, 1887.

[6] Therapeutic Gazette, March 15, 1888, p. 153.

℞	Precipitated sulphur (pure), . . .	ʒ jss.
	Chocolate powder, ...	ʒ j.
	Cinnamon-water (concentrated, 1 in 40),	fl. ʒ j.
	Glycerine, ...	fl. ℥ iij.

Mix the powders in a mortar; then gradually add the glycerine with constant trituration, and lastly the cinnamon-water. Dose, half a teaspoonful to a teaspoonful every hour or oftener. Dr. Knaggs reports the treatment of seventy-five cases of diphtheria by this drug alone, with no fatal result.

Rapid disappearance of membrane and corresponding general improvement are said to have followed the use of sulphurous acid in teaspoonful doses every half-hour to every two hours according to the gravity of the case.[1]

Hyposulphite of soda has been used during the past year by Dr. J. H. Fruitnight,[2] of this city, in connection with iron and other appropriate treatment in thirty cases with successful result in all but two. The remedy has been used in the strength of ʒ j—ʒ jss—ʒ ij (according to the age of the patient) in two fluid-ounces of water, and of this a teaspoonful has been given every two hours. In a few of the cases the solution has been applied with a brush or with the atomizer, the gentlest possible mode of application being always preferred.

CHLORINE, BROMINE, AND IODINE.

Free chlorine, bromine, and iodine are among the most powerful bactericides. Chlorine kills bacteria in a watery solution of the strength of $\frac{1}{22,000}$; bromine in that of $\frac{1}{2500}$, and iodine in that of $\frac{1}{1500}$. In internal use their germicidal effect is greatly diminished by their conversion in vital fluids which contain alkalies (as, for example, blood-serum) into chlorides, bromides and iodides. Their principal utility as antiseptics in the treatment of diphtheria is therefore in their local effect.

For cleansing and deodorizing a foul diphtheritic throat, solutions of chlorine have long been much prized, and are among the most efficient agents in our possession. The best of these is the liquor sodæ chloratæ, from two to four fluid-drachms of which in eight fluid-ounces of water may be applied every hour or two by gargling, irrigation or atomization.

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[1] Dr. H. L. Snow, British Medical Journal, Oct. 8, 1887, p. 773.

[2] Archives of Pædiatrics, October, 1888, p. 601.

There has been much testimony to the successful employment of bromine in the treatment of diphtheria; but this experience of its utility has been by no means universal. Like many other powerful antiseptics it may doubtless be in skillful hands an effective therapeutical weapon against diphtheria; but its use in full strength or slight dilution is opposed by the considerations which have been referred to in regard to corrosive and irritating applications generally, and in high dilutions it has not been shown to have greater curative efficacy than other less disagreeable remedies. It is recommended by Dr. Hiller[1] in the following combination:

℞ Potassii bromidi,
Bromi, ... āā gr. iv.
Aquæ dest., ... ℥ vj. ʒ ij.
M.

To be applied by brush to the pharynx every two or three hours and also used by inhalation.

Dr. P. Hesse,[2] from his experience with one hundred and fifty cases, regards bromine as the most valuable local application in diphtheria. He used a solution of five decigrammes (gr. ⅝) each of bromine and bromide of potassium in two hundred grammes (℥ vj. ʒ ij.) of water applied locally every two or three hours and also dropped on the sponge of an inhaler and so used for five minutes every half-hour. Latterly he used the solution by inhalation only, varying its strength according to the severity of the case.

Dr. W. H. Thomson has employed bromine successfully in the treatment of a large number of cases of diphtheria, by a method of which the following account is abbreviated from a fuller statement by himself which is contained in "A Treatise on Diphtheria" by Dr. A. Jacobi: Lawrence Smith's solutio bromini is first prepared by the following method: "Take two ounces of a saturated solution of bromid. potass. in water; add to this, in a bottle, with constant shaking, one ounce of bromine. It is better to add a part and then let it stand awhile before adding the rest. Then fill up gradually, and with constant shaking, with water, until it measures four ounces." It should not be ordered in a mixture with either glycerine or sugar, as it is thereby decomposed. If not exposed to too strong a light it keeps for several days.

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[1] Deutsche Med. Wochenschr., 1882, ix., 22, p. 328.

[2] Deutsches Archiv. f. Klin. Med., 1885-6, xxxviii., p. 479.

Locally this solution, mixed with an equal part of glycerine, or, in some cases, in full strength, is applied to the membrane with a hair-pencil as gently as possible. If the membrane is very extensive and the parts much swollen or difficult to reach, one half a drachm to one drachm of the solution to the pint of warm water is applied by douching with a Davidson's syringe.

Internally from six to twelve drops of Smith's solution in a tablespoonful of sweetened water is given every hour, two, or three hours, according to the urgency of the case, and continuously, no other medicine being taken until the disappearance of the membrane. It should be swallowed promptly, as the disagreeableness of bromine is due much more to its fumes than its taste.

Tincture of iodine has long been much employed as a local application in diphtheria, and many reports attest its efficacy as a caustic and antiseptic in causing the shrivelling and rapid disappearance of membrane. It has also been much used in such combinations as the following:[1]

℞ Tinct. iodi.,
Tinct. ferri chloridi, . . . āā fl. ʒ j.
Acidi carbolici, ... gr. x.
Glycerini, ... fl. ℥ ss.
M. Apply by brush several times daily.

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[1] Dr. Keating, Boston Med. and Surg. Journ., 1885, Jan. 22.

It has also been used internally; as by Dr. E. Adamson[1] who treated fifty-five cases, including some very bad ones, with doses of two or three minims in syrup aurantii and water every two hours to a child of six years with only two fatal results. The same remarks as to its great utility and its inferior eligibility to some other drugs in the treatment of diphtheria, both in stronger and weaker solutions, apply to iodine as to bromine, though in a somewhat less degree.

Iodoform.

"It is now regarded as an established fact that iodoform is not a parasiticide. . . . It is believed by some to have a destructive effect on the ptomaïnes generated by the bacteria through the action of the free iodine or iodine compound which is liberated."[2] It cannot be doubted that iodoform has a valuable antiseptic action, and its local anæsthetic effect and tendency to diminish secretion render it valuable in the treatment of diphtheria. It is important, however, that its use should be preceded or accompanied by other disinfectant measures.

It may be applied in powder, by brush or insufflator, pure or mixed with half its weight of starch or with three parts of sugar. Good results in preventing the extension of membrane down the trachea after tracheotomy, by the insufflation of iodoform through the tube, have been reported by George Shirres[3] (who thus used ten to fifteen grains every four hours in two cases) and others.

The following solution to be applied by pencilling is recommended by Le Gendre:[4]

Iodoform . .	2.50	grammes	(38 grains).
Balsam of tolu .	5	"	(75 minims).
Ether . . .	25.	"	(6 ¼ drachms).

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[1] Practitioner, London, July, 1885, p. 16.

[2] American Journal of the Medical Sciences, October, 1888, p. 401.

[3] London Lancet, July 24, 1886, p. 164.

[4] Archiv. de Laryngol., No. 1, 1887.

Dr. G. Mundie[1] prefers the application of iodoform to the throat in ethereal solution by spraying. The ether appears to constringe the congested capillaries, and the iodoform is deposited in a thick film on the surface.

Iodoform has been regarded by many as an especially valuable agent in the treatment of the diphtheria of wounds. Its successful use in diphtheritic invasion of the tracheotomy wound has been reported by Plenio[2] and others in the form of powder, iodoform-vaseline or iodoform-collodion. It may be mixed with either of these excipients in the proportion of one to eight.

Iodol has a similar action and like applicabilities to those of iodoform.

CHLORAL.

Hydrate of Chloral, first recommended in the local treatment of diphtheria by Dr. Accetella,[3] of Italy, has since been much employed and highly prized by many. It is an efficient antiseptic, hindering the development of bacteria in the strength of $\frac{1}{1000}$. It is also a powerful irritant to raw or especially sensitive surfaces. Applied to the affected part by brush every hour or two in the form of the officinal syrup of chloral of the British Pharmacopœia (ten grains to the drachm), it promptly arrests fœtor and is said to cause the rapid solution and disappearance of membrane.

Dr. A. Mercier[4] gives internally the syrup of chloral of the French codex (one in twenty) in doses of two, three or five grammes every half-hour or hour, no drink being allowed for some time afterward. In forty-eight hours after the treatment is begun the false membrane has dissolved and disappeared, when the further use of the chloral becomes painful.

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[1] London Lancet, June 5, 1886, p. 1103.

[2] Jahrb. f. Kinderh., Bd. xxii., H. 4.

[3] Campania Medica, No. 12, 1873.

[4] Le Concours Méd., Aug. 27, 1887, p. 411.

By this treatment, Dr. Mercier has saved ninety-five out of one hundred cases.

OXYGEN.

Oxygen is one of the most powerful of disinfectants and antiseptics. It has been principally employed in the treatment of diphtheria, locally by means of the permanganate of potassium, locally and internally in peroxide of hydrogen, and as conveyed through the blood to the tissues by means of the salts of iron.

From the readiness with which it parts with oxygen, permanganate of potassium is a powerful antiseptic, and in a solution of the strength of from three to five grains to the ounce of water is a most valuable local application in the treatment of diphtheria. Dr. Mason[1] prepares a stock solution of two drachms of the permanganate in three ounces of distilled water, and uses a teaspoonful of this solution in one ounce and a half or two ounces of water as spray. It promptly arrests fœtor, which does not return.

Peroxide of hydrogen, though not a new substance, has of late been brought prominently forward as an especially valuable antiseptic in the treatment of diphtheria, and in the hands of some has, like most new remedies, produced brilliant therapeutical results. Such results have been claimed by Vogelsang[2] and by Hofmokl.[3]

Dr. M. P. Hatfield,[4] of Chicago, has used it successfully in eighteen cases, applied by swab every two hours, or a spray of the liquid diluted with seven times its bulk of water. He states that it neither acts as a solvent to, nor prevents the formation of, false membrane, but neutralizes its poison.

The form in which this agent has been most generally used in this city is the Marchand solution, which contains fifteen volumes of the gas. Dr. H. Gifford,[1] having in a series of experiments demonstrated that this preparation promptly kills bacteria and their spores, adds, "The instructions accompanying the Marchand solution advise diluting with about four times its bulk of water for use on 'mucous membranes as injections, etc.' A dilution of this strength was found not to have killed the pus cocci after an exposure for thirty minutes, a result which practically bars it as a germicide, though for its cleansing action it may still be valuable . . . . . The fifteen volume solution is sharply irritating to the conjunctiva and nasal mucous membrane, and even the weakest solution mentioned in the announcement, instead of being 'bland as water,' causes considerable smarting of the eyes and nose for a few minutes."

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[1] Brooklyn Medical Journal, May, 1888.

[2] Archiv. f. Kinderh., B. viii., H. 2, p. 113.

[3] Wiener Med. Presse, 1886, xxvii., 18, 19.

[4] Archives of Pædiatrics, Feb., 1888, p. 102.

I have tried the Marchand solution in several cases of diphtheria, including one adult one, and my experience with it accords with that of Dr. Gifford as to its somewhat irritating and unpleasant effect when used with only slight dilution. In each case it was a relief to the patient and therapeutically advantageous when its use was discontinued and my usual spray of carbolic acid and lime-water was resumed.

In a case related to me by another physician in which the peroxide was employed early and frequently both as spray and internally, the duration of the disease was not shortened thereby, and the patient died just at the time of apparent recovery from the usual effects of toxic absorption, which the remedy had failed to counteract.

In so far as I have been able to judge of its effects the peroxide of hydrogen, though it is a valuable antiseptic, has no greater curative efficiency in the treatment of diphtheria than the solutions of chlorine or of permanganate of potassium, with which remedies it may be classed; but is to be preferred to them on account of its less disagreeable taste.

The application of ozone by the inhalation of ozonized air has been from time to time recommended in the treatment of diphtheria—the ozone being produced by a chemical process in an inhaler. Dr. Seneca D. Powell a few years since exhibited to the Post-graduate Clinical Society of this city an inhaler in which ozone is generated by the action of electricity, and which he had used with good effect in various diseases, among which was diphtheria in several cases—its effect having been the rapid disappearance of false membrane and the correspondingly rapid reduction of temperature. I am informed by the deviser of this instrument, Mr. Harvey Lufkin of the C. & C. Electric Motor Company, that it will soon be manufactured and offered for sale.

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[1] New York Medical Record, Sept. 1, 1888, p. 243.

BENZOATE OF SODIUM.

Benzoate of Sodium has only a mild antiseptic action, since in a solution of $\frac{1}{200}$ it merely hinders the growth of anthrax bacilli (Koch). Letzerich, having been led by the experiments of Graham Brown to the conclusion that it is fatal to the microbe of diphtheria, and consequently a specific for that disease, employed it therapeutically with nearly uniform success by the following formula:

℞	Sodii benzoat, ...		ʒ j. gr. xv.
	Syr. aurantii, ...		ʒ ijss.
	Aquæ menthæ pip.,		
	Aquæ dest., . . .	āā	℥ j., ʒ ij.
	M.		

To be given in divided hourly doses in the twenty-four hours. He subsequently increased the daily dosage to from 1¾ to 3¾ drachms to children under fifteen years, and from 3¾ to 5½ drachms for older patients.

From this and similar uses of it favorable results have been reported by Kien, Ferréol and many others, the most notable being those related by Brondel,[1] who claimed to have treated two hundred cases with uniform success by the following method: He gave hourly a tablespoonful of a solution of the benzoate (fifteen grains to the fluid ounce), together with one sixth of a grain of the sulphide of calcium in syrup or granule, and sprayed the throat every half-hour with a ten per cent. solution of the benzoate. He also employed vaporization of water containing carbolic acid, turpentine and oil of eucalyptus.

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[1] Bulletin Gen. de Thérap., Nov. 15, 1886, p. 416.

Favorable results from the use of the benzoate of sodium have not, however, been obtained by all who have employed it. Thus Guandige, of Vienna,[1] among seventeen children treated by the method of Letzerich, had eight deaths. While there is reason to believe that this agent has positive therapeutical value, the hope that it would prove to be the desired specific has not been realized.

CHLORATE OF POTASSIUM.

Chlorate of Potassium has long held a leading place among valuable remedies in the treatment of diphtheria. It is a mild antiseptic, and its effect in favorably modifying catarrhal inflammation in the mucous membrane of the mouth and throat is well established. It is to this effect upon the inflammation that its utility in the treatment of diphtheria is doubtless mainly due.

The important fact that chlorate of potassium is in excessive doses a most dangerous poison has been illustrated in quite numerous instances. Dr. V. Afanasieff[2] has collected from international literature fifty-one such cases, forty-six of which were fatal. He has also found by experiments on animals that in acute cases of poisoning by the chlorate of potash there is rapid and profound disorganization of the blood, its detritus accumulating in the liver, spleen, lymphatic glands, bone-marrow and kidneys, the urinary tubules becoming blocked up and impassable, the renal functions ceasing and acute parenchymatous nephritis with uræmic poisoning resulting. In chronic cases, parenchymatous nephritis is soon followed by intense interstitial nephritis with its usual consequences; and in all cases the blood assumes a characteristic chocolate color.

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[1] Quoted by Le Gendre, loc. cit.

[2] "St. Petersburg Inaugural Dissertation," 1885, Abstracted in Provincial Medical Journal, March, 1888, p. 134.

The cases of poisoning referred to have been the result of taking at one dose known quantities of the salt varying from three to ten drachms, or the reckless swallowing of large quantities of a saturated solution or super-saturated mixture.

These facts show that this drug, like most other valuable therapeutical agents, is a poison when used in certain quantities, and make it incumbent on physicians not only to exercise due moderation in the doses of it which they prescribe to their patients, but also to correct the prevailing popular belief that it can safely be taken in unlimited quantities; but they do not teach that when used in suitable doses and in proper dilution it is liable to have an injurious cumulative effect, which is indeed contradicted by a vast array of experience.

Dr. H. Seeligmüller[1] refers to the experience of Dr. von Mering as corroborating his own, that the chlorate of potassium is a most valuable remedy, and is only dangerous when given on an empty stomach, so as to be rapidly absorbed into the circulation in large quantity. Dr. Seeligmüller's doses (from half a tablespoonful to a tablespoonful of a five per cent. solution hourly) are large enough to require this caution in their use.

Dr. Hüllmann,[2] of Halle, who uses a four per cent. solution in hourly doses of from a teaspoonful to a tablespoonful, has always had good results and never any bad effects therefrom. In twenty years he has used this remedy for 3511 patients, including 571 cases of diphtheria. Among the latter he has had only six deaths. In diphtheria he has used also lime-water and weak solutions of permanganate of potassium locally. He regards chlorate of potassium as the best of all remedies which have been proposed for the treatment of diphtheria. Similar statements have been made by many.

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[1] Deutsche Med. Wochenschr., 45, 1883.

[2] Deutsche Med. Wochenschr., 52, 1883.

During the past twenty years I have prescribed the chlorate of potassium in thousands of cases of sore throat and scarlatina, and in many hundreds of cases of diphtheria, usually in a four per cent. solution. Many of these patients have taken it in teaspoonful doses hourly or half-hourly for several weeks continuously. In no instance have I observed or had any reason to think that its effect has been injurious. So far from its having occasioned kidney affections in my cases of scarlatina and diphtheria, the infrequency of nephritis and albuminuria has been remarkable even in many very grave cases of the latter disease.

I have never regarded it as a specific, but rather as a valuable adjuvant in the treatment of diphtheria, and have usually employed it in connection with other remedies. (See page 219).

BORAX.

Borax is a very valuable antiseptic. It is especially adapted to local use in the treatment of diphtheria by its bland and unirritating character, its cleansing effect, and its harmlessness in ordinary doses. It has therefore been much employed in the form of the glycerine of borax applied by brush; in powder, by insufflation; and in a watery solution of the strength of from one to five per cent. by gargling or irrigation.

The following combination is recommended by Le Gendre:[1]

℞. Boracis,	
Potassii chloratis, ...	āā gr. 75.
Acidi carbolici, ...	gr. 4.
Glycerini, ...	ʒ 2½.
Mellis, ...	ʒ 7½.

M. To be applied with pencil.

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[1] Archiv. de Laryngol., No. 1, 1887.

Dr. Noël[1] has lately announced that he has given borax internally with good results in the following doses:

To children under one year .	8 to 15	grains	daily
" " from two to five years	15 to 23	"	"
" " " five to ten years	30	"	"
" adults	45, 60 or 75	"	"

These quantities are given in solution in divided doses hourly.

The drug produces abundant salivation. Dr. Noël thinks that, being eliminated by the salivary glands and the muciparous glands of the throat, it tends to soften and remove the false membrane. This was the only medicine given during an epidemic to sixty patients, of whom only two or three died.

Boracic acid has been preferred and employed by some. It may be locally applied in saturated solution and used as a gargle or in spray in a solution of the strength of from one to three per cent.

OIL OF TURPENTINE.

Oil of Turpentine is a powerful antiseptic. In a solution of the strength of $\frac{1}{75,000}$ it hinders the growth of bacteria. The vapor of oil of turpentine mixed with air arrests the secretion of mucus. The drug when taken internally is partly excreted by the lungs and acts on the mucous membrane, lessening its secretion; but a watery solution of it applied to inflamed mucous membranes increases secretion and diminishes vascular congestion. Large doses are liable to act as a purgative, and moderate ones are apt to cause dysuria and hæmaturia.

Oil of turpentine has been used by some as a local application. Schmiedler[2] prefers it to any other. He applies it pure in cases in which the seat of the affection is accessible every three hours, and finds that it is unirritating, rapidly dissolves false membrane, and has a very decided antiseptic action.

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[1] Le Concours Méd., May 26, 1888.

[2] Rev. Mens. des Mal. de l'Enf., June, 1888.

There is much recent testimony to the benefit derived from the internal use of oil of turpentine in the treatment of diphtheria, especially in the laryngeal form of the disease.

Bosse[1] gave eight grammes (two drachms) to children of from two to seven years of age, and twelve grammes (three drachms) to older patients, pure, followed by milk, once daily in forty-three cases, including very severe ones, with distinct effect in modifying and shortening the disease, and with only two fatal results.

Dr. Satlow[2] followed Bosse's method in forty-three severe cases, adding one gramme (♏xv.) of ether to fifteen grammes (f. ʒ iij., gr. xlv.) of turpentine to diminish its nauseating effect. In three cases the imminent necessity of tracheotomy was obviated by the treatment, and only three per cent. of his patients died.

Dr. Roese[3] treated fifty-eight cases by the following method: Teaspoonful doses of oil of turpentine (with four minims of ether in each dose) were given three times a day. A tablespoonful of a two per cent. solution of salicylate of sodium was given every two hours; a warm one per cent. solution of potassium chlorate was used as a gargle, and an ice-bag was applied externally. His results were, rapid subsidence of fever and subjective symptoms, no exacerbation of the local affection after the commencement of treatment, obviation of the danger of asphyxia, except in one case in which tracheotomy was performed, and decided shortening of the duration of the disease. The turpentine was discontinued as soon as the fever had subsided and the local symptoms had improved. In most cases not more than from three to five drachms were required, though in several instances as much as fifteen drachms was employed. Only three of his patients died.

Dr. A. Sigel,[4] in the Olga Hospital in Stuttgart, treated forty-seven cases, including some very grave ones, with turpentine in teaspoonful doses once or twice daily, with seven deaths, or 14.9 per cent. In four of these cases the necessity of tracheotomy was imminent, but was averted by the treatment. Of sixteen other patients treated with salicylic acid, chlorate of potash, etc., seven died, or 43 per cent., and of twenty-four treated with sublimate six died, or 25 per cent.

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[1] Berlin. Klin. Wochenschrift, No. 43, 1880, and No. 10, 1881.

[2] Deutsche Med. Zeitschrift, 1883, p. 157.

[3] Therapeutische Monatschefte, October, 1887.

[4] Arch. f. Kinderh., vi., 2.

Dr. S. Baruch,[1] from his favorable experience in the use of this remedy in 39 cases, says: "In only one case have I observed temporary hæmaturia; in none strangury . . . . I administer ol. terebinth. in doses of one drachm to half an ounce to children from six to fourteen years of age, once a day, oftener in cases demanding it. It may be given pure, followed by milk or mixed with milk or in emulsion. Vomiting occurs sometimes after the first dose, but it is usually retained afterwards. In about fifty per cent. of the cases it produces a laxative effect. It always stimulates the secretions of kidneys and skin; the odor is quickly detected in these as well as in the fæces."

In the Oldenburg Hospital for Children in St. Petersburg, 264 of 296 very grave cases of diphtheria were treated in 1882, according to the report of Dr. Lunin,[2] in different groups by the following remedies and with the following results in "fibrinous" and "septic" cases respectively:

TREATMENT.	FIBRINOUS FORM.			SEPTIC FORM.			TOTALS.		
	Cases.	Deaths.	Percentage of Deaths.	Cases.	Deaths.	Percentage of Deaths.	Cases.	Deaths.	Rate Per Cent.
Bichloride . .	43	13	30.2	14	13	92.9	57	26	45
Chloride of iron	43	14	32.6	51	39	76.5	94	53	56
Chinoline . .	19	6	31.6	9	9	100	28	15	53
Resorcin . . .	10	2	20	19	17	89	29	19	65
Bromine . . .	15	7	46.7	18	16	88.9	33	23	69
Turpentine . .	12	1	8.3	11	9	81.8	23	10	43
							264	146	55.3

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[1] "Therapeutical Memoranda on Diphtheria, with Special Reference to the Value of Large Doses of Oil of Turpentine," New York Medical Record; Dec. 24, 1887, p. 784.

[2] St. Petersburg Med. Wochenschr., 6 and 7, 1885.

The bichloride was applied locally by brushing with a $\frac{1}{1000}$ solution every two hours and irrigation with a $\frac{1}{5000}$ solution hourly.

The chloride of iron was given in doses varying from one drop every two hours to two drops every half-hour, with irrigation every hour by a three per cent. solution of boric acid.

Quinoline was applied every two hours in five per cent. solution in water and alcohol, and used by irrigation or spray in $\frac{1}{550}$ solution.

Resorcin was applied in ten per cent. solution every two hours, and used in one per cent. solution as gargle or spray.

Bromine was used in $\frac{1}{200}$ solution, applied every one to three hours, and in a solution two thirds of that strength inhaled every half-hour to every hour.

Turpentine was given in doses not exceeding ten drops hourly for periods of from two to ten days, with a gargle of a three per cent. solution of boric acid.

In thirty-two additional cases treated by other methods there were eighteen deaths, or 56 per cent. The mortality in the entire series of 296 cases was therefore 164, or 55.4 per cent.

These figures show the best results from turpentine in the fibrinous form, and the worst from bromine; the best from chloride of iron in the septic form, the worst possible from chinoline, and nearly as bad from bichloride of mercury.

ANTISEPTIC AEROTHERAPY.

Oil of turpentine has been much employed by vaporization. It may be poured from time to time into a vessel in which water is kept constantly at boiling point, and the vapor may be allowed to diffuse itself through the air of the room or conducted through a tube near to the patient's mouth. Dr. Delthil[1] recommends that in cases of no especial gravity it be evaporated by placing it in a suitable vessel which is set into another one containing water which is kept at a temperature of 60° C. (140° F.). The turpentine should be crude, not rectified. In a large room several such receptacles should be used.

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[1] Journal de Méd. de Paris, July 12, 1886.

He recommends the employment of antiseptic fumigations in grave cases by the following method: A mixture of two pounds of coal tar, four ounces of oil of turpentine, two drachms of resin of benzoin and three and one quarter ounces of cajeput oil, or a mixture of seven ounces of coal tar and two ounces and six drachms of turpentine, or turpentine alone may be used. About two ounces of either is poured into a large metallic dish, and then lighted and allowed to burn steadily, renewal being required about once in two hours. A small room should be used for the purpose, into which the patient may be carried and allowed to remain for half an hour at a time, after which he may be returned to the regular bedchamber, in which the evaporation of turpentine by the method previously described is maintained. Dr. Delthil has found that the fumes are well tolerated by patients, and reports favorable results from this method of treatment in one hundred and twenty-six out of one hundred and thirty-four cases.

Renou[1] reports the successful employment of the following method of antiseptic aërotherapy: On one or two small kerosene stoves water is kept constantly at the boiling-point. Into this is put every two hours one or two drachms of the following mixture: Alcohol, 468 grammes; carbolic acid, 280 grammes; benzoic acid, 112 grammes; and salicylic acid, 156 grammes. The apparatus must be so placed that the vapor can be readily inhaled by the patient.

EUCALYPTUS.

Dr. J. Murray-Gibbes[2] extols the virtues of eucalyptus used in the following manner: The patient is kept in an improvised tent, and the air is charged with vapor impregnated with the oil of eucalyptus, by placing the dried leaves in a vessel of boiling water beside the bed. This should be renewed every half-hour. The patient is kept in this atmosphere until the disease has disappeared. Dr. Murray Gibbes has, since 1881, treated 163 patients in this way, with only one death, though other physicians have lost many patients. A colleague has treated 305 cases in the same manner with only one death.

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[1] Bulletin de Soc. de Méd. d'Angers, 1885, xiii., p. 112.

[2] London Lancet, 1883, i., p. 316, and Australian Medical Journal, October 15, 1888.

Thymol, which is a powerful antiseptic, has been utilized in the treatment of diphtheria. It may be used by the following formula, as gargle or spray:[1] Thymol, ʒ j.; Glycerine, ʒ iij.; Water, ℥ jss. Oil of peppermint, which is also strongly antiseptic, has been found efficient used "freely and copiously" as a local application twice daily in the early stage of diphtheria.[2] The insertion into the nostrils of plugs of cotton saturated with a twenty per cent. oily solution of menthol in cases in which the nares were entirely occluded with membrane is said to have caused its rapid disappearance and the arrest of the diphtheritic process.[3] Engelmann[4] has found that vinegar is a most efficient antiseptic. Used pure for local application, diluted with two or three parts of water as spray, and with four parts of water as a gargle, it has given better results than any other agent. It is energetic without being irritating. It also possesses in a high degree the power of penetrating animal tissues. Citric acid in the form of lemon-juice has also been highly recommended by Fieuzal[5] and others.

Dr. Jules Simon, of Paris,[6] employs the following local treatment: Local application every hour by day, and every two hours at night of lemon-juice or vinegar or pure red wine, and gargling or irrigation every two hours with a luke-warm solution of boracic acid (1:25) or borax (1:50) or potass. chlorat. (1:25) or lime-water or vinegar-water.

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[1] Dr. Da Costa, N. Y. Med. Record, Feb. 27, 1886.

[2] Dr. L. Braddon, London Lancet, March 24, 1888.

[3] Cholewa, in Therap. Monatsch., 1888, 11, p. 284.

[4] Centr. f. Klin. Med., 1886, No. 14.

[5] Bull. de la clin. nat. ophth., vol. vi., p. 57.

[6] Rev. Mens. des Mal. de l'Enf., August, 1885.

Hydronaphthal with Papaïn.

Dr. W. C. Caldwell,[1] in order to accomplish at the same time the solution of false membrane and local disinfection in the treatment of diphtheria, has combined a peptonizing ferment and an antiseptic in one mixture. Having referred to the general tendency of the latter class of substances to prevent the action of the former, he states that, nevertheless, in one case of diphtheria in which he used bichloride of mercury with papaïn, "the pseudo-membrane was readily dissolved, and the temperature fell from 103° to 99° from nine A. M. to six P. M. . . . Hydronaphthal is a powerful antiseptic which acts in a neutral or acid menstruum, and, besides, is not poisonous. When it is used with papaïn to spray the throat in diphtheria, the membrane rapidly dissolves."

Dr. Caldwell has employed the following mixture in the treatment of seven cases of diphtheria:

℞ Papaïn, ...	ʒ ij.
Hydronaphthal, ...	gr. iij.
Acidi hydrochlorici dil., ...	gtt. xv.
Aq. destil., ...	ad ℥ iv.
M.	

This was applied by "spraying the throat every half-hour until temperature is reduced and breathing is easy; then every hour, unless asleep. In these cases, when the spray was used thoroughly, the temperature fell in from four to eight hours." To be effective, the spray must be thoroughly and directly applied to the affected surfaces. In the seven cases referred to, the result of the treatment was favorable in all but one—a laryngeal case in which cyanosis was present when treatment was begun.

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[1] Archives of Pediatrics, February, 1889, p. 97.

THE CHLORIDE OF IRON.

So great a mass of clinical evidence as to the value of the chloride of iron in the treatment of diphtheria has been presented to the profession, and that value is now so generally recognized, that it would be superfluous to adduce statistics to prove it. The occasional denials of its efficacy, based on experience of its unsuccessful employment, which appear in medical literature, may be regarded as merely illustrating the indisputable fact that it is not a specific, and that its usefulness is subject to limitations.

The local astringent action of the drug has already been referred to; it is also a valuable local antiseptic. Internally it is undoubtedly the most efficient known antidote to the poisonous action of the putrefaction-products of diphtheria in the system at large. It evidently does not produce this effect by destroying the microbes of the disease, but by reinforcing the vital processes by means of which the poisons produced by them are resisted, destroyed and eliminated. The tendency of these poisons, when absorbed into the circulation, is to the rapid production of anæmia and hæmic disorganization, nervous prostration, and the consequent arrest of all vital functions. "Ferric salts, after absorption into the blood, increase not only the number of the blood-corpuscles, but also the percentage of hæmoglobin contained in them, and may also cause a little free iron to be contained in the serum. By thus increasing oxidation in the tissues they increase the functional activity of all the organs. . . . . . Iron also circulates with the bile, and it is probable that the beneficial effects of large doses may be due to the action of the iron upon the liver." (Brunton.) Iron is also a tonic to the vascular system, and ferric chloride has been supposed to have an especial stimulant action on the nervous sytem.

The internal administration of the chloride of iron has little effect on the duration of the membranous affection. In the laryngeal form of the disease it is probably useless, except to oppose concomitant blood-poisoning, and as a tonic. In the distinctively inflammatory stage and form of diphtheria its value is mainly limited to its local astringent and antiseptic action in the pharynx. Its special and unequalled utility is seen in its preventing or limiting the occurrence of constitutional poisoning and counteracting its effects in the septic form or stage of the disease. Its power to accomplish this object is, however, not unlimited. It is inadequate in cases in which the constitutional poisoning is especially rapid and intense, and in many cases in which other essential antiseptic measures are neglected, as, for instance, the cleansing of the nares in nasal diphtheria.

There are unfortunately other limitations to its utility. In quite a number of cases it is irritating to an especially sensitive throat, and it sometimes causes vomiting. These effects may depend on the injudicious manner of its administration, but in some cases its use in any form is inadmissible.

The administration of large amounts of the drug is considered by many a *sine qua non* to obtaining its beneficial local and constitutional effect.

Dr. Aubrun,[1] in 1860, recommended its use in very frequent doses. His usual mode of administering it was to have from twenty to forty drops of an aqueous solution of the perchloride, consisting of one part of the anhydrous salt in three parts of water, put into a cup of water, and of this two teaspoonfuls were taken by the patient every five minutes while awake, and every fifteen minutes while sleeping. Robert Druitt,[2] in 1861, practiced and recommended giving it in doses as large as two drachms every two hours. Both of these physicians reported favorable results from this heroic medication, and like results from similar practice have been reported by many subsequent writers.

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[1] Gaz. Med. de Paris, Nov. 26, 1860, p. 765.

[2] British Medical Journal, Feb. 23, 1861, p. 208.

Dr. A. Jacobi[1] says, "To be of any efficacy muriate of iron must be given in large doses, frequently repeated. Five to fifteen drops every quarter, half, or every hour is a dose that alone fairly tests the effective powers of the medicine."

Dr. J. E. Winters[2] makes the important discrimination that "where there is marked sepsis and tendency to capillary hæmorrhages the dose should be larger than in a case of a less septic and more marked inflammatory character," and recommends that in the former type of the disease at least one drachm of the tincture should be administered every hour to a child two to five years old.

In those cases in which a marked tendency to septic poisoning is manifested the use of the drug should, if necessary, be pushed toward the limit of tolerance, and from one to three ounces daily may succeed where less would fail. But such heroic dosage is, in actual practice, especially in the treatment of young children, attended with grave difficulties, and is fortunately in the great majority of cases unnecessary. When other appropriate treatment is employed, from one and a half to three drachms of the tincture of iron given daily will usually have the desired effect.

It has also been considered necessary by some that the tincture of iron be administered in concentrated form. While this may doubtless enhance its beneficial local effect in some cases, it may have an irritating effect in others. But the great objection to administering it in this form to children is the fact that its unpleasant acrid and styptic taste, and the smarting which it often occasions is very liable to arouse their violent opposition to taking it and necessitate struggles, the undesirableness of which has already been alluded to. That this is no merely fanciful or unusual result I know from observation in many cases. The evil referred to may be obviated in most cases by giving the tincture of iron in six or eight parts of glycerine. (See formula page 220.)

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[1] American Journal of Obstetrics, 1875, p. 660.

[2] Loc. cit.

QUININE.

Quinine has been much employed in the treatment of diphtheria as an antiseptic, an antipyretic and a tonic.

It hinders the growth of anthrax bacilli in a solution of the strength of $\frac{1}{830}$ and prevents it in that of $\frac{1}{625}$. It may doubtless exert a valuable local antiseptic action, but is inferior in this respect to other agents which are less disagreeable to the taste.

High temperature is generally limited to the early and inflammatory stage of the disease, and then other measures for reducing it are more efficient and appropriate than antipyretic doses of quinine.

For tonic effect in the later stage of the disease, and in the period of convalescence, quinine, in doses of from half a grain to a grain or two, three or four times a day, or the compound tincture or wine of cinchona, or the elixir of calisaya, may be very useful.

The unpleasant bitterness of quinine and its consequent tendency to excite nausea are important obstacles to its use in the treatment of diphtheria in young children.

ALCOHOL.

The antizymotic and antiseptic actions of alcohol are well known. It hinders the growth of anthrax bacilli in a dilution of 1:100, and prevents it in that of 1:12.5. Its main utility, however, in the treatment of diphtheria probably results from its assisting to maintain nutrition and opposing the tendency to adynamia and heart-failure by its action as a food and a stimulant.

The principal indications for its use are the following:

When milk or other food is refused by the patient or taken only in insufficient quantities, the addition of a little brandy or wine will sometimes cause it to be relished and taken more freely and will also promote its digestion.

In marked depression of the vital powers from the combined effects of fever, prolonged suffering, fatigue, loss of sleep, and an insufficiency of nourishing food, even if the symptoms of septic poisoning are absent, alcoholic stimulants, carefully and moderately administered, may have a valuable sustaining effect, as in other diseases.

At the first appearance of symptoms which denote constitutional poisoning by the septic products of the disease, such as pallor with weakness, enfeebled heart-action, etc., alcoholic stimulants should be administered. The quantity and frequency of the doses must depend on the gravity of the symptoms, the effect of the remedy in controlling them, and the tolerance of the stomach. The symptom to be especially regarded is the pulse. If that be feeble and unduly slow or rapid or irregular the amount of stimulant given must be increased, if possible, until its favorable effect is manifested. Intoxication in the ordinary sense of the term is not usually produced under these circumstances. The amount given must often be large, and may sometimes be heroic. I have in many instances given three or four ounces of brandy or whiskey daily in teaspoonful doses, well diluted, every hour or half hour to children under five years of age, without injurious effect, and in some cases with evident benefit. I have repeatedly seen it given in more than twice that quantity, but although favorable results are reported from this use of it where less has failed, I have never seen an instance of them.

Brandy or whiskey may be given in the form of milk punch or made into a toddy or diluted with carbonated waters; or egg-nog or wine-whey, or Malaga, Burgundy or port wine may be more acceptable to the patient, and sometimes champagne has a particularly good effect.

The most important limitation to the giving of alcoholic stimulants in diphtheria results from the intolerance of them by the stomach. When in every form they are found to excite repugnance or nausea and to thus prevent the taking of other food, persistence in their use can only be injurious. The possibility of causing subacute gastritis by giving too strong and too frequent doses of alcoholics should not be forgotten. "Sometimes when given very freely to support the failing circulation, they have this effect, the result of which is that both food and stimulants are vomited, and the patient is brought to death's door." (Brunton.) In view of the close sympathy which is well known to exist between the condition of the stomach and the function of the heart through the nervous system, it is evident that the irritation or overtaxing of the former by too heroic stimulation may inhibit the latter, and thus produce the very condition of heart-failure which it was intended to prevent.

The indications for the use of alcohol which have been stated by no means justify its indiscriminate use in the treatment of diphtheria. It is not called for in the early stages of most cases. It is in no sense a specific for diphtheria. It should be remembered that when it is used without indication or in excess of the quantity indicated, though it may in some cases be well tolerated, it is yet a poison. It is especially liable to be so to the delicate organizations of children. "Absorbed into the blood it lessens oxidation, and will consequently diminish oxidation in the tissues." (Brunton.) "In certain circumstances, such as febrile diseases, it may be a very useful food; but in health, when other foods are abundant, it is unnecessary, and as it interferes with oxidation it may be a very inconvenient kind of food." (Ibid.) "By increasing the circulation it may stimulate the functions of all the nerve-centres and render them for the time being capable of greater activity, ... but its action on the nerve-centres themselves is a paralyzing one. . . . . Its action on the nerve-tissues seems to be one of progressive paralysis." (Ibid.) "In the Ashantee campaign the effect of alcohol as a stimulant compared with beef-tea was carefully tested. It was found that when a ration of rum was served out the soldier at first marched more briskly, but after about three miles had been traversed the effect of it seemed to be worn off, and he then lagged more than before. If a second ration was then given its effect was less marked, and wore off sooner than that of the first. A ration of beef-tea, however, seemed to have as great a stimulating power as one of rum, and not to be followed by any secondary depression." (Ibid.)

The wise therapeutist, in the treatment of diphtheria, as of other diseases, will reserve this most valuable agent to aid him in tiding his patient over those crises in which its use is definitely indicated, rather than attempt by its early, indiscriminate and excessive administration to prevent their occurrence—an attempt which will too often tend to defeat its own object.

In proportion as other and more appropriate measures for preventing the occurrence of serious septic poisoning and sustaining the strength of the patient are early and efficiently carried out, the proportion of cases in which the use of alcoholic stimulants is called for is diminished. I was thus enabled to say in my second report (see page 212): "The large majority of cases in the present series, as in those that I have previously reported, have been treated absolutely without them." That the cases of which this could be stated were neither doubtful nor trivial ones was conclusively shown in the reports referred to. All my subsequent experience and observation have tended to confirm my belief that in a large majority of all cases of diphtheria *which are early and well treated* the indications for the use of alcoholic stimulants which have been referred to do not present themselves, and that their use without those indications is not advantageous, but the reverse.

Dr. J. Lewis Smith[1] relates the following typical experience: "Although an advocate of the liberal use of alcohol, I cannot regard this agent as a specific. When I commenced serving in the New York Foundling Asylum in May, 1878, the quarantine wards contained four children between the ages of three and five years who had been sick a few days with severe diphtheria, and it was evident at a glance that they must soon perish with the ordinary mild sustaining treatment. Quinine, iron, the most sustaining food and a moderate amount of alcoholic stimulants were being given, and we determined to increase the Bourbon whiskey to a teaspoonful every twenty to thirty minutes, day and night. Nevertheless, whatever the result might have been with the earlier commencement of this treatment, the blood-poisoning was now too profound, and one after the other died."

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[1] Diseases of Children, p. 319.

Those who, unlike Dr. Smith, regard the heroic use of alcohol as a specific for diphtheria, explain such failures by the lateness and insufficiency of its administration. I know of no ground for the assumption, either in our knowledge of its action or the statistics of treatment. I have seen quite a number of cases, some of them in my own earlier practice and others in consultation, in which as free use of alcohol as that just referred to was begun at the outset of grave and malignant cases, and failed as signally to arrest the fatal progress of the disease. Our main dependence for effecting that object must be on the early employment of other and more appropriate measures, to which alcoholic stimulants may often be a most valuable, and sometimes an indispensable, adjuvant.

SPECIFICS.

Copaiba and Cubebs.

Copaiba and cubebs were formerly very extensively used, especially in France, in the treatment of diphtheria. Dr. Trideau[1] claimed to have employed them with rapidly successful effect in more than three hundred cases. The former remedy having been generally abandoned on account of its irritant effect upon the digestive organs the latter continued to be much used. It was given in the form of the oleoresin, either in capsules or in emulsion with syrup of acacia, in doses of from 1.50 grammes (22½ minims) to 3 grammes (45 minims) daily. M. Sanné,[1] having employed this treatment in a great number of cases, states that he has never observed from it any well demonstrated action which can compensate for the disgust which it inspires in patients and its tendency to excite purgation.

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[1] Traitement de l'angine couenneuse par les balsamiques, Paris, 1874.

CARDIAC DEPRESSANTS.

Veratrum Viride.

The employment of depressing remedies, except to fulfill some imperative and temporary indication, is generally condemned and avoided in the modern treatment of diphtheria. From what has been stated elsewhere (page 71) as to the usual character of the disease in its early stages, it is evident that this exclusion should not be too indiscriminate and arbitrary. The following statements by Dr. J. M. Boyd,[2] of Knoxville, Tennessee, in so far, at least, as they relate to the early stage of certain types of the disease, are worthy of consideration:

The characteristic pulse of diphtheria is described as "rapid," "small," "hard," "tense," "wiry." The speedy reduction of this rapidity to the normal or sub-normal rate has in his experience been followed by the mitigation of the inflammatory process and the melting away of false membrane. He employs for this purpose the tincture of veratrum viride, commencing with moderate doses, according to the age of the patient, and increasing them until the desired effect upon the pulse is produced. To an adult he gives three drops of Norwood's tincture every two hours, increasing by one drop at each dose until the pulse-rate is brought down to sixty or seventy per minute. One child two years of age required five drops and another seven drops every two hours to bring the pulse under control. When nausea results the dose must be increased cautiously and omitted occasionally. Dr. Boyd regards this practice as unattended with danger. He accompanies it with the use of other appropriate remedies. In proof of its value he refers to his successful employment of it in sixty-seven cases of unquestionable diphtheria, including a fair share of malignant ones. He finds the most probable explanation of its efficacy in the view that by slowing the tired heart, it gives the rest which is so important to the recuperation of nerve-force.

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[1] Op. cit., p. 402.

[2] New York Medical Record, 1888, 33, p. 627.

The Treatment of Diphtheria by Irrigation.

Dr. G. Guelpa[1] advocates the treatment of diphtheria by the early, persistent, copious and very frequent washing of the parts which are affected by the disease or are threatened with its extension, whether in the pharynx, nares or elsewhere. The medicinal agent to be employed is a secondary consideration. Mild solutions of the chloride of iron have proved most successful in his hands, but he admits that other solutions, as of lime, carbolic acid or boric acid may be equally serviceable. The fountain-syringe or nasal douche may be used in the milder cases, but when the resistance to the passage of fluid requires it, more forcible methods should be resorted to. The irrigations should be practiced every quarter of an hour by day and every half-hour at night. Dr. Guelpa reports the successful employment of this method in a long series of cases at different periods.

The Method of Treatment which has been Employed by the Author.

In a paper read before the New York Academy of Medicine in March, 1876,[2] I presented statistics of one hundred and seventy-nine cases of diphtheria, one hundred and twenty-four of which had been visited by me in the North District of the Demilt Dispensary (the eastern part of the Twenty-first Ward of this city) in an epidemic of the disease which occurred in 1875. That the epidemic in that locality had been especially severe was shown in the paper referred to and the subsequent discussion by statistics of the Board of Health and also by the testimony of other physicians.[1]

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[1] Bulletin Gén. de Thérap., 1887, pages 255, 313, 362.

[2] "Diphtheria and its Treatment, with Statistics of One Hundred and Seventy-nine Cases," Transactions of the New York Academy of Medicine, 1876, p. 286.

The results of the treatment employed in these cases were that in ninety-eight of the one hundred and twenty-four dispensary cases in which it was tested with some degree of fairness, though under very unfavorable conditions, there were ten deaths, or about ten per cent. In the remaining fifty-five cases which were treated by the same method under more favorable conditions by the late Dr. E. J. Darken, Dr. W. E. Bullard and myself, there were only two fatal results.

In a communication to the New York Medical Record (January 12, 1878, page 21) I reported the statistics of thirty-seven dispensary cases which had been treated by my assistant physicians, Dr. W. E. Bullard and Dr. D. C. Comstock, and myself in 1876—the results being that in thirty-two of them in which the treatment had been tested with some degree of fairness there had been three deaths, or, again, a little less than ten per cent.

That these very favorable results might not be confounded with the numerous reports of brilliant therapeutical triumphs based on inaccurate diagnosis or the exceptional mildness of the cases treated, I again in 1880 presented to the Academy a report[1] of equally good results obtained by the same methods of treatment in forty consecutive dispensary cases, the genuineness of which and the severity of a large proportion were kindly attested from personal examination either by Dr. A. H. Smith or Dr. W. T. White, most of the cases having also been seen by a number of other competent physicians.

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[1] Dr. H. T. Hanks said: "Dr. Billington's success was truly remarkable, for he well knew the type of the disease as it had appeared in the Twenty-first Ward, having had, in his private practice during the last five years in that district, from twenty to thirty cases every year. He knew that many of the cases attended by Dr. Billington had been severe, and not a few malignant. Therefore when the large per cent. of recoveries was considered a cause must be looked for; and he believed that two excellent reasons could be found for this satisfactory result. One was the kind of medicaments used locally and internally, and the other was the great care he bestowed in teaching the parents or nurses the proper manner of administering the remedie [illegible] ed. This carrying out to the letter every little detail has had [illegible] more than many have been led to suppose, in the cure of [illegible]

The treatment described in the first of the reports referred to consisted mainly in the use of the tincture of the chloride of iron, potassium chlorate, salicylic acid (in solution with the sulphite of soda), glycerine and lime-water, by frequent internal administration, carbolic acid and lime-water by very frequent spraying, and the thorough cleansing of the nares in nasal diphtheria by syringing them with tepid salt water. Its most essential features are: (1) the most efficient possible local disinfection, (2) without irritation, (3) by frequent applications, which are (4) so pleasant as not to arouse the opposition of children nor unnecessarily to annoy and fatigue older patients, this being accomplished (5) by means of formulæ and other details which were precisely stated and their importance insisted on.

To avoid unnecessary repetition, these particulars and their application in the treatment of the various stages and forms of diphtheria will be subsequently stated in connection with such additional therapeutical measures as my own later experience and the experience of others have shown to be most worthy of confidence.[2] Those which are now especially referred to may be found on pages 215, 216, 219, 220, 225 and 226.

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[1] "Forty Attested Cases of Diphtheria, with Remarks on Diagnosis and Treatment," New York Medical Record, March 27, 1880, p. 333.

[2] It is proper to state in this connection that Dr. A. Jacobi, in a paper entitled "Contributions to the Pathology and Therapeutics of Diphtheria," which was read before the New York County Medical Society in December, 1874,—more than a year before the reading of my

Testimony to their successful employment of this mode of treatment has been given by many physicians either in published statements or in letters which have been received by me from all parts of this country and Canada.

Some of these letters have borne witness to its efficacy not only in diphtheria as it occurs in this city, but also in malignant epidemics in distant localities. An especially interesting and instructive statement to that effect from Dr. T. Clowes Brown, of Fredericton, New Brunswick, Canada, was published by me, with his permission, in the New York Medical Record, January 12, 1878, page 23.

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first paper—and published in the American Journal of Obstetrics, vol. vii., page 628, advocated the treatment of the severer forms of diphtheria by large and frequent doses of the tincture of iron; the treatment of "simple tonsillar diphtheria" with "frequent small doses of a chlorate combined with lime-water, or tinct. ferr. mur. ʒ ss—ʒ ij. a day, and generally mixed with a little glycerine, principally for the purpose of keeping the remedy in longer contact with the diseased surface, if not for its own antifermentative effect;" and the treatment of nasal diphtheria by thorough cleansing and disinfection of the nares by syringing them every hour or every half hour with "two to four grains of carbolic acid to the ounce of water," or, "where there is no smell, lime-water, pure or somewhat diluted, for its solvent effect."

This mention is made proper by the priority of Dr. Jacobi's publication, and the coincidence in our therapeutical recommendations in respect to the drugs principally employed and the distinctive principles which I have above enumerated as 1, 2, and 3.

In reference to these circumstances I made, in a foot-note to my first report above referred to, the following statement:—"There is, in my opinion, more essential and valuable truth in this little monograph" (Dr. Jacobi's) "than can easily be found elsewhere. It should be carefully perused by all students of this much perplexed subject. It is proper to state that while I coincide with Dr. Jacobi's views in almost every particular I am not his 'follower,' except in the order of publication. My own pathological conclusions and my present mode of treatment were independently arrived at (as many of my friends know) before his paper was written or I knew anything of its author's views."

In the New York Medical Record, Feb. 23, 1878, page 158, I published a letter from the late Dr. E. J. Darken, who was House-Physician to Demilt Dispensary from 1869 until his death in 1886, which gave precise confirmation to the latter statement.

THE TREATMENT OF THE EARLY STAGE OF PHARYNGEAL DIPHTHERIA.

The special indications at this stage of the disease are local disinfection, the subduing of inflammation and the reduction of fever.

The patient should be put to bed in a clean, well-ventilated and yet sufficiently warmed apartment, from which unnecessary articles of furniture have been removed.

If the attack shows a tendency to severity and is attended with marked febrile symptoms, calomel should be given, either in a single purgative dose of from two to ten grains according to age, or, preferably in most cases, in divided doses of from one fourth of a grain to one grain mixed with sugar and placed upon the tongue every half hour, every hour or every two hours, until a purgative effect is produced.

Ice in small pieces, or in the form of water-ices, is usually grateful to the patient and should be given frequently, and he should be permitted to drink ice-cold water freely if he craves it.

Frequent cool sponging, especially about the head, face and neck, is often soothing and agreeable. If there is a marked tendency to glandular swelling, compresses frequently wrung out of ice-water, or ice-bags, may be applied over the affected region.

If the patient is seen at the initial stage of the disease when the false membrane has not yet acquired much thickness or density, and if his age and the accessible location of the affection make it practicable, its abortive treatment may be attempted. The affected spot or spots, having been cleansed by spraying or irrigation and then dried by gently touching them with absorbent cotton, may be carefully touched with a solution of the bichloride of mercury ($\frac{1}{1000}$ to $\frac{1}{500}$) by means of a camel's hair brush or a soft swab applied with gentle pressure. This may be repeated every two hours (a mild antiseptic or solvent spray being frequently employed in the intervals) if its effect seems to be good, but if, in spite of a few such applications, the local affection increases, its further use should be abandoned as only likely to aggravate the irritation.

For the purpose of rapidly dissolving the false membrane solutions of pepsine, trypsin or papäin may in some cases be advantageously employed at this stage of the disease by very frequent topical applications or spraying, as has been described on pages 167 *et seq.*

Under the same circumstances the application of various caustic or astringent antiseptic agents, such as the nitrate of silver, the tincture of iodine, concentrated solutions of carbolic or salicylic acid, resorcin or chloral, which have been referred to in the preceding portions of this chapter and the mode of using them described, may doubtless in some cases arrest the disease at its outset. The favorable experience of some in the use of such agents has been stated, and also its limitations and dangers. It has formed no part of my usual treatment. My favorable experience in this use of Monsel's solution or the tincture of the chloride of iron has been referred to, but even that may be ineffective and irritating.

If the patient is old enough to permit it, the throat should be sprayed with some mild, solvent, antiseptic and antiphlogistic liquid as frequently as is practicable. I know of none which so admirably combines these qualities or has so good an effect under ordinary circumstances as the following mixture:[1]

℞ Acidi carbolici, ... ♏ x.
Aquæ calcis, ... fl. ℥ iv.

M. S.—To be applied by spraying for some minutes every half-hour.

This mixture has the important advantage of being more agreeable to the patient in its taste and after-effect than any other that I know of. Many children will permit its use that would oppose that of any other. The proportions are important, since the addition of a few drops more of the carbolic acid makes it pungent and disagreeable. That in a solution of this strength ($\frac{1}{192}$) carbolic acid is an efficient antiseptic and antiphlogistic has been shown on page 180. The valuable utility of lime-water has also been shown on page 165. The spray thus administered should be *fine*, as coarse sprays are unpleasant and irritating to diphtheritically inflamed surfaces. Some atomizers which are now in very general use are objectionable in the treatment of diphtheria for this reason.

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[1] This formula was published by me in 1

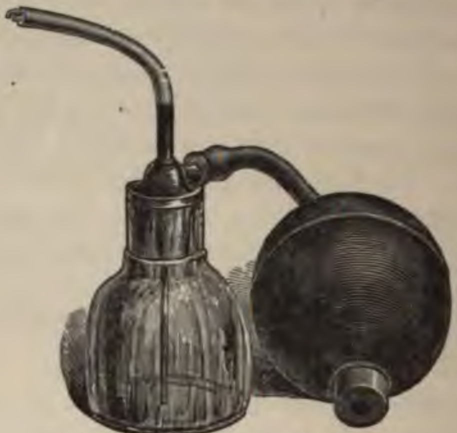

Fig. 10.—The Delano (No. 558) Atomizer.

The Delano atomizer makes a fine spray, and is in every respect a convenient and suitable instrument.

All atomizers which throw a fine spray are liable to be obstructed by solid particles. Nurses should always be taught how to remove this obstruction by means of the fine wire which comes in the box with the atomizer, or with a bristle. When the Delano atomizer cannot be obtained, the Davidson instrument will serve a very good purpose, and has, indeed, some special advantages.

The point of the atomizer should not usually be thrust into the throat of the patient, but should be held several inches from the open mouth. The spray is thus diffused over the whole surface of the palate and pharynx. In most cases in which the mouth is opened widely, the spray, if good aim is taken, reaches the pharynx freely. In some cases, however, it is necessary to carry the point of the atomizer further back over the tongue or to depress the tongue. The patient, when old enough, can usually be taught to do this, using a tongue-depressor in which the handle is at a right or obtuse angle to the blade. Nurses or parents must always be carefully instructed in the proper use of the atomizer.

Other mild antiseptic sprays may render valuable service in cleansing and disinfecting the mouth and throat, as, for instance, solutions of permanganate of potassium (3 to 5 grains to the ounce), peroxide of hydrogen (one in four of water), bichloride of mercury (one in 4000 to 10,000), borax or boracic acid (one to three per cent. solution), salicylic acid (one in 500 to 2000), etc. The special utilities and drawbacks of these and other valuable substances, and also the manner in which they may be employed, have already been stated.

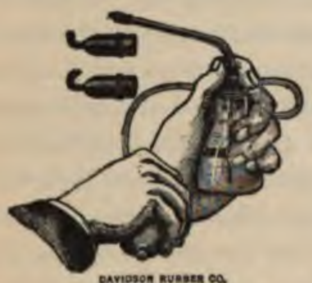
DAVIDSON RUBBER CO.

FIG. 11.—Davidson Anatomizer, No. 59.

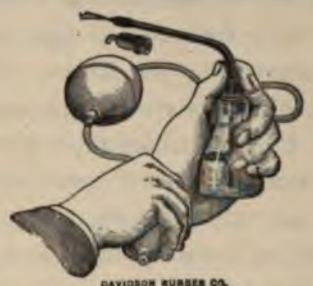
DAVIDSON RUBBER CO.

FIG. 12.—Davidson Anatomizer, No. 6.

When the solvent ferments are applied by spraying, the point of the atomizer should be carried nearer the membrane to be dissolved than has been directed in other cases, that the solvent may be concentrated upon it.

When the patient is too young to voluntarily permit the use of the spray (most children over three years of age can with tact be taught to take the pleasant one I have described) its use should not be attempted, and reliance must be placed on internal administration and irrigation. Mild antiseptic washes can be applied by the latter method when their use is indicated by the presence of viscid and offensive secretions in the mouth and throat. A hard-rubber syringe with a straight, slender, and smoothly rounded tip should be used. According to the valuable suggestion of Dr. Guelpa[1] it is not necessary to force the teeth open, but the tip of the syringe may be slipped between the teeth and the cheek, toward the angle of the jaw, and fluid injected will freely enter the mouth and pharynx behind the last molars. The utmost gentleness should be observed in doing this; it should not be repeated oftener than once in two or three hours, and never unless it is indicated by the presence of offending material which cannot be otherwise readily dislodged. I once shared the enthusiasm of Dr. Guelpa for the treatment of pharyngeal diphtheria by irrigation, but my own further experience has been that while it has valuable uses, it may easily be made excessive, irritating and injurious. Warm salt-water (one drachm to the pint) or either of the mild antiseptic solutions just referred to is a suitable liquid to employ.

The necessary cleansing of the throat may usually be effected by the frequent internal administration of suitable remedies.

Internal Medication.—Antipyretics.—It should be remembered that high fever at this stage of the disease in primary and uncomplicated cases is the concomitant of the inflammation, and that its reduction is to be sought mainly by the employment of the antiseptic and antiphlogistic measures which have now been referred to. When it is excessive and persistent I know of no antipyretic drug which will usually, according to my experience, give such satisfactory results as the salicylate of soda. It may be given in doses of from two to fifteen grains in from a teaspoonful to a tablespoonful of water hourly or every two hours, according to the age of the patient and the degree of fever, which doses may be increased, diminished or discontinued according to the effect produced. With a suitable diet its tendency to excite nausea will not often be manifested, and this may be further counteracted by adding to each dose of the solution, when given, an equal quantity of cold Vichy or seltzer-water from a siphon-bottle.

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[1] Loc. cit.

If the patient is robust, aconite, in doses of a fraction of a drop of the officinal tincture every half hour or oftener may sometimes be advantageously given for a short time at this stage of the disease.

In case the salicylate of sodium is not tolerated or proves ineffective, antipyrin or antifebrin may be resorted to if its effect is urgently called for. The former may be given in doses of one and a half grains for every year of the child's age, every hour for three times, if necessary, and the latter in one fourth of these doses. I have never found the use of either of these drugs necessary except in diphtheria complicating or following scarlatina. Cold or warm sponging is often a useful and agreeable adjuvant. Quinine in antipyretic doses is rarely if ever appropriate in the early stage of diphtheria.

In the great majority of cases I prescribe from the outset the chlorate of potassium and the chloride of iron.

The utility of these drugs has been remarked upon on pages 191 and 200. I have most usually prescribed them separately and in alternation in the following mixtures,[1] which are especially appropriate and pleasant, and are usually readily taken by young children:

No. 1.

℞	Potassii chloratis, ...	℈ij.—℈iv.
	Glycerini, ...	fl. ℥ss.
	Aquæ calcis, ...	fl. ℥iijss.
	M. S.—A teaspoonful every hour.	

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[1] These formulæ are identical with those published by me in 1876.

No. 2.

℞	Tinct. ferri chloridi, . . .	fl. ʒ ij.—ʒ iij.
	Glycerini, ...	fl. ℥ ij.
	Aquæ, ...	ad. fl. ℥ iv.

M. S.—A teaspoonful every hour.

Number two is given in half-hourly alternation with number one. The weaker form should generally be used for children under three years of age.

Or the two drugs may be thus combined:

No. 3.

℞	Tinct. ferri chloridi, . . .	fl. ʒ ij.—ʒ iij.
	Potassii chloratis, ...	℈ ij.—℈ iv.
	Glycerini, ...	fl. ℥ ij.
	Aquæ, ...	ad. fl. ℥ iv.

M. Dose, a teaspoonful every hour, or every half-hour.

The proportion of glycerine in these formulæ is important —especially in the treatment of children—not merely for its demulcent and slightly solvent action, but mainly for its covering the unpleasant acridity of the tincture of iron.

The indications for discontinuing or increasing the doses of the tincture of iron have been pointed out on pages 201 and 202. When it is desired to increase them, this should be done, in the case of children, not by increasing the proportion of iron in the mixture, but by giving larger quantities of the mixture at a dose, and at shorter intervals.

In some cases the use of the following mixture[1] at an early stage of the disease has seemed to have a particularly good effect in causing the rapid disappearance of membrane and reducing fever:

℞	Acidi salicylici, ...	gr. x.—℈ j.
	Sodæ sulphitis, ...	ʒ ss.—ʒ j.
	Glycerini, ...	fl. ℥ ss.
	Aquæ, ...	fl. ℥ ijss.

M. S.—A teaspoonful every hour.

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[1] This formula was published by me in 1876.

In this solution the antiseptic action of the salicylic acid is retained. It may be given instead of number one in half-hourly alternation with number two or number three.

I have used it only during the first two or three days of the disease. Number one is usually to be preferred in the case of young children.

The bichloride of mercury may be given in connection with the treatment already described. Its valuable effect is undoubtedly the greater the earlier its use is begun. Its use is not indicated in mild cases of simple pharyngeal diphtheria, but is appropriate in the early stage of severe ones, and especially in those in which laryngeal implication is threatened, either by the symptoms of the patient or the character of the prevailing epidemic. Its special utility and dangers and the various modes of administering it have been referred to on pages 175–177. It should, under the circumstances now considered, be given in doses of from $\frac{1}{100}$ to $\frac{1}{50}$ of a grain, according to age and the severity of the disease, hourly, in at least a dessert-spoonful or a tablespoonful of water, milk or other beverage, or, preferably, in many cases, according to the experience of Dr. F. Huber, in half these doses half-hourly. Or, to avoid the unnecessary multiplication of doses, it may be added to formula number two or number three, as in the following prescriptions:

℞	Hydrargyri bichloridi,	. gr. $\frac{2}{10}$—gr. $\frac{3}{10}$.
	Tinct. ferri chloridi, . . .	fl. ʒ ij.—ʒ iij.
	Glycerini, ...	fl. ℥ ij.
	Aquæ, ...	ad. fl. ℥ iv.
	M.	

Or,

℞	Hydrargyri bichloridi, . .	gr. $\frac{2}{10}$—gr. $\frac{3}{10}$.
	Tinct. ferri chloridi, . .	fl. ʒ ij.—ʒ iij.
	Potassii chloratis, . . .	℈iv.
	Glycerini, ...	fl. ℥ ij.
	Aquæ, ...	ad. fl. ℥ iv.
	M.	

From one one-hundred-and-fiftieth to one one-hundredth of a grain of the bichloride is thus given in each teaspoonful. From one to two teaspoonfuls may be given hourly or half-hourly. It should preferably be given after the taking of food or drink. It cannot be too often repeated that its effect must be carefully watched. Its use should not ordinarily be continued longer than three or four days.

The strong evidence in favor of the valuable utility of the internal use of oil of turpentine has been referred to (see page 194). That I have never employed it is due to my aversion to the use of measures in the treatment of diphtheria which are in themselves repugnant to the patient, and tend to produce nausea and disturbance of the digestive functions. Since it need usually be given only once a day it must be admitted that this objection thereby loses much of its force. Its special applicability seems to be, like that of mercury, rather to the more superficial or "fibrinous" rather than the deeper or "phlegmonous" form of the disease, and consequently to laryngeal rather than pharyngeal diphtheria. Its most valuable effect is obtained from its early employment. The usual dose is from a teaspoonful to a tablespoonful in milk or emulsion.

Various other remedies which have been referred to and the manner of employing them described on preceding pages of this chapter may be internally administered or locally applied at this stage of the disease with valuable effect, such as the cyanide or the biniodide of mercury (see page 177), sulphur, sulphurous acid, the hyposulphite of soda (pages 182 and 183), iodine (page 185), iodoform (page 186), chloral (page 187), benzoate of sodium (page 190), peroxide of hydrogen (page 188).

One or another of these drugs may doubtless in some cases be advantageously substituted for, or used in connection with, those which have now been especially recommended; but it is important to remember that the undue multiplication of remedies is particularly undesirable in the treatment of diphtheria, and that from among those which promise equal efficiency the one which is the most pleasant to the taste, the most acceptable to the stomach, and the least irritating in its local effect should always be chosen.

The diet in pharyngeal diphtheria should always consist of liquids or semi-solids. In the early stage of the disease it should be bland and simple, but nutritious. Milk has been my principal reliance in the great majority of cases, especially of children. It should be given, if possible, in the quantity of from four to six or eight ounces every two hours, but when only smaller quantities can be taken at once the frequency with which it is given must be proportionally increased. The physician must himself realize, and impress upon his patients and nurses, that the taking of sufficient nourishment is a matter of prime and vital importance. It must be insisted on, however difficult and painful the effort of swallowing may be. The ingenuity and perseverance of the physician and the nurse must often be exerted to the utmost degree to effect this object. Even when the act of swallowing is most painful and repugnant to a child, he can usually be induced to take a little milk or other food after each dose of medicine or spraying of the throat or syringing of the nose.

If milk is rejected by the stomach, the addition to it of lime-water in smaller or larger proportions, up to one-half, will often have a good effect. It may sometimes be advantageously alternated with beef, mutton or chicken-tea, or oyster or clam-broth. Though abundant nutrition is imperatively demanded in diphtheria, it is a serious error to overload the stomach with rich or concentrated foods during the febrile stage of the disease. In those cases in which milk is unfortunately not tolerated, it may sometimes (though too rarely) be made available by peptonizing it, or koumyss may be a valuable resource, or the addition to milk of a little brandy or whiskey with or without sweetening may furnish the solution to the problem. When milk in no form is tolerated the reliance must be on farinacious gruels, meat-teas, juices, extracts and broths, beef-peptones, light custards, egg-nog, etc., the skill of the nurse in such devices being an important element of success. All other methods failing, nourishment by the rectum is indeed a resource—but a desperate one.

The use of alcoholic stimulants is not usually indicated in the earlier stage of pharyngeal diphtheria, except under the circumstances and in the manner just referred to. In exceptional cases in which the strength of the patient has been reduced by previous illness, or in those malignant types of the disease in which septic poisoning with its depressing constitutional effects is evident from the first, the indication for their use is obvious and imperative.

In order to economize to the utmost the strength of the patient, the administration of medicines and nourishment, which, in the treatment of diphtheria, is necessarily frequent, should be as systematic and regular as is practicable, and should be so arranged as to give the patient the longest possible intervals of rest between them. The giving of medicine, the use of the spray, and the taking of nourishment should for this reason usually come in immediate succession (though sometimes in the opposite order), that the remainder of the half-hour may be appropriated to rest. But the patient must be promptly aroused at its termination, and this punctuality and regularity must be insisted on, except at night, when an hour's undisturbed sleep may in most cases be occasionally permitted. In order to secure the coöperation of tender-hearted parents in this apparent cruelty, it is important to strongly impress upon their minds its absolute necessity.

THE TREATMENT OF NASAL DIPHTHERIA.

As nasal diphtheria is a very frequent complication of the more serious forms of the pharyngeal affection, its treatment should be considered before proceeding to that of the later stage of the disease.

From the special danger of septic infection which attends this form of diphtheria, results the imperative indication of the cleansing and disinfection of the nasal passages. It is essential that the physician realize that this is to be effected, not by the introduction into them of a little mildly antiseptic fluid, but by the most thorough removal from them of their poisonous contents which is practicable. It is also highly important that this be accomplished with the least possible irritation, annoyance or fatigue.

The instruments which may be employed for the purpose are the syringe or douche or the nasal atomizer. The use of the latter requires for its efficiency a coarse spray forcibly driven, the effect of which, in the treatment of diphtheria, is at once more irritating and less thorough than that of a stream from a syringe properly used.

The syringing of the nares is necessarily somewhat unpleasant to the patient, and usually provokes the violent resistance of young children. When bunglingly performed it may be most distressing, ineffective and injurious.

The struggles of young children and the consequent danger of exhaustion and injury are best prevented by the well directed use of overmastering force combined with manual dexterity and gentleness. Much experience has taught me the advantages of the following method:

The assistance of two persons is required. The child is seated across the lap of one of these persons, who secures his hands with one of her own, and with the other holds a basin to receive the discharge. The other person stands behind the child, takes his head between the palms of her hands, and, leaning forward, holds it firmly against her breast. A third person who should, when possible, be a physician, can then easily make the injection into the child's nostrils without danger of injury to them by its sudden movements.

When the child is thus firmly held, or in the case of older patients, any small syringe will answer in careful and skilful hands; but under other circumstances one should be used which has a blunt and soft tip. It should also have a ring in the handle, that it may be conveniently manipulated by one hand. The hard rubber half-ounce ear-syringe is in most respects a very suitable instrument; but its tip should either be cut off, as was suggested by Dr. S. W. Smith,[1] or, still better, should be padded,—a device which was recommended by Bre-

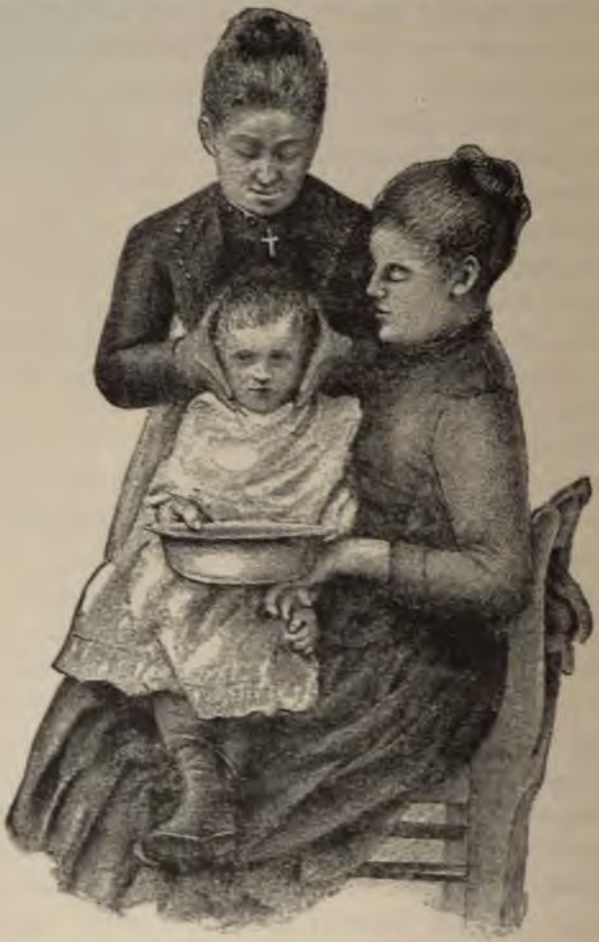

FIG. 13.—Manner of Holding a Child for Nasal Syringing.

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[1] New York Medical Record, 1886, 29, p. 354.

tonneau.[1] This is easily done by surrounding it with absorbent or other cotton and fastening over this a perforated piece of rubber-cloth, oiled silk, chamois-leather or muslin, as is shown in figure 16. As this requires but a moment, the padding may be changed after each syringing.

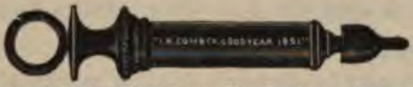

FIG. 14.—Hard Rubber Half-Ounce Ear-Syringe. (Reduced Size.)

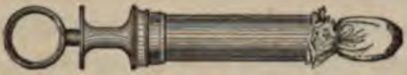

FIG. 15.—Ear-Syringe Padded.

A glass syringe expressly designed for this purpose, the nozzle of which is protected by a covering of soft rubber, is manufactured by R. Van der Emde, 323 Bowery, New York, and is called "Peerless Syringe, No. 4."

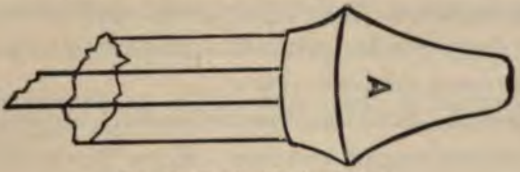

FIG. 16.—Peerless Syringe, No. 4.

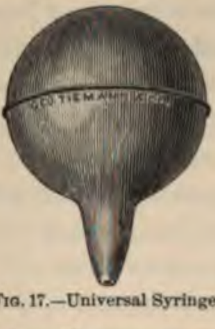

FIG. 17.—Universal Syringe.

An instrument which will serve very well in most cases is the "universal syringe" made by Tiemann & Co., which is entirely of soft rubber.

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[1] Fifth Memoir.

Warm salt-water (one drachm to the pint) is admirably suited to the purpose. The addition to it of bichloride of mercury (one grain to the pint) or of borax (one or two drachms to the pint) or of salicylic acid (four grains to the pint) is regarded as an improvement by some.

The fluid should be thrown with force enough to make it flow out, partly by the other nostril and partly by the throat, if the passages are pervious. If they are not so, more forcible injections may be employed, and these, with a little perseverance, will usually succeed. Undesirable as these may seem, the removal of the obstructing mass should be regarded as imperative. Tearing away or boring through the membrane should not be resorted to on account of the great danger of its causing epistaxis. The very frequent application of pepsin, trypsin or papayotin by means of a medicine-dropper may be of service in very obstinate cases.

The injections should be repeated on each occasion until the passages are thoroughly cleansed. From two or three to five or six applications to each nostril are usually sufficient to accomplish this.

When the operation is thus thoroughly performed, I have found by experience in many cases that its repetition from two to four times in the twenty-four hours is usually sufficient to secure the desired effect. Its repetition with unnecessary frequency is to be deprecated, since it is more or less unpleasant and irritating and consequently fatiguing, even to adults, from the especial susceptibility of the nasal mucous membrane, and much more so to children who have to be coerced, and in the treatment of bad cases of this disease the strength cannot be too carefully economized. When it is only partially or imperfectly done, as it must be by only a single injection into each nostril on each occasion, as is practiced by some, it of course becomes necessary much oftener.

When the syringing of the nares has to be entrusted to nurses, they must be carefully instructed by the physician as to all its details, such as the angle (more nearly horizontal than perpendicular) at which the syringe is to be introduced, etc., and even then he will too often have the pain of finding that it has been very imperfectly or badly executed.

I have dwelt at such length on the details of nasal syringing, because, whatever may be thought of the utility of various other therapeutical measures in the treatment of diphtheria, there can be no doubt that upon this one the saving of many hundreds of lives every year directly depends. If it is neglected in severe cases of nasal diphtheria the patient is almost sure to die; if it is efficiently performed the greater proportion recover.

THE TREATMENT OF THE LATER STAGE OF PHARYNGEAL AND NASAL DIPHTHERIA.

The special indications for treatment in the later stage of diphtheria are:

1. To continue local measures for antiseptic effect.
2. To counteract the effects of constitutional poisoning.
3. To sustain the strength of the patient.
4. To appropriately deal with complications which may arise.

In a large majority of all cases which have been treated early and efficiently by the methods already described, the disease will have been so favorably modified by them, in limiting the extension and moderating the intensity of the local affection and preventing or minimizing the absorption of poison, that they may be without difficulty conducted to complete recovery, after a duration of from four to twelve days, by the continuance of the mild solvent and antiseptic local treatment, the internal administration of chloride of iron and the chlorate of potash and the measures for nutrition and rest which have been recommended.

In a much smaller proportion of cases, which, however, varies considerably in different epidemics, in which the disease is from the outset of especial severity or malignancy, and of the deeply infiltrated or "phlegmonous-septic" type, and in other cases in which treatment is begun only at an advanced stage of the malady, an arduous and prolonged conflict with it is yet to be waged.

At this stage in such cases, hyperpyrexia has usually disappeared along with the acute intensity and tendency to rapid extension of the local inflammation, and evidences of constitutional or septic poisoning present themselves.

It is of the utmost importance that the physician realize that his chief resource in order to prevent the system being fatally overwhelmed by this poison is in diminishing the amount introduced into the circulation by the *most thorough possible cleansing of the sources from which it is absorbed.*

The means for effecting this object, namely, washing them with suitable antiseptic solutions, applied by internal administration, spraying and irrigation, have already been described. If they are neglected or only inefficiently employed, it will too often be found that no amount of stimulation or other internal medication will avail to save the patient.

I have in many instances, after beginning the treatment of a case at this stage of the disease, seen the pallor and sallowness of the skin soon replaced by natural tints, apathy and somnolence disappear, nausea and vomiting cease, the dull eye become bright, the feeble and flickering pulse become full and regular, simply or mainly from the effect of these measures. In some of them heroic stimulation and medication, previously employed under other direction, had failed to produce any favorable effect.

This good effect is often manifested in spite of the persistent presence of quite extensive membranous deposits. In this case the effect of the antiseptic washes is doubtless exerted not only by their removing from all the surfaces much poisonous material which would otherwise be absorbed, but also by their penetrating in some degree the false membrane itself, and thus causing, by osmotic action and the interchange of fluids, more or less diminution, dilution and disinfection of the noxious products of the disease lying beneath it.

The denser and thicker the false membrane is, the less, of course, can the latter effect be produced. Hence the difficulties in the way of thorough local disinfection are often very great and sometimes insuperable, especially in the cases of young children. When masses of thick membrane oppose it, these may, if accessible, be softened and thinned by the frequent application of the solvents which have been referred to, or in some cases by the careful application of such agents as Monsel's solution, which tend to shrivel and disintegrate them and restore tone to the relaxed and infiltrated tissues.

Adenitis, in such cases, often presents a serious obstacle to antiseptic endeavors, since the diphtheritically inflamed glands are in themselves inaccessible foci of infection. In the treatment of this complication, it must still be remembered that the first indication is by the local antiseptic measures just referred to, to prevent or limit the absorption of more poison through the lymphatics into the glands. The adenitis itself may be let alone or treated with cold or warm applications. If there is febrile temperature and the adenitis is increasing, ice-bags may be applied. If the adenitis is no longer increasing and is not especially annoying, it is best let alone. If, in the later stage of the disease, the tumors are large and painful or show a tendency to suppuration, they should be treated with warm poultices. The application of ointments of iodine or iodoform or mercury is probably useless. All irritant applications to the skin should be avoided. The application of the linimentum belladonnæ, mixed with half the quantity of glycerine, has in some cases seemed to me to have a soothing and beneficial effect.

The second and third indications above referred to, though distinct, are yet to be mainly fulfilled by the same means, namely, the chloride of iron, abundant nourishment, alcoholic stimulants and appropriate tonics.

The pre-eminent utility of the chloride of iron in enabling the system to withstand the effects of diphtheritic poisoning has been remarked upon on page 200. When this condition is present it must be freely administered. Formula number two (page 220) should be used, and of this mixture from one to two teaspoonfuls may be given every half-hour, according to age and tolerance, or in very urgent cases, every twenty minutes.

The maintenance of abundant nutrition is of primary importance. Not only is this essential for sustaining the strength, but it is practically an antiseptic measure, since the less is the supply of nourishment to the system, the greater is the absorption of poison. If milk is freely taken it is still the most suitable food, but, in view of the tendency to the failure of strength, more stimulating articles may often be advantageously added to the dietary. Among the most useful of these is the freshly expressed juice of underdone beef in small quantities, or Valentine's beef-juice. Concentrated and predigested food-preparations, such as the various "beef-peptones," "liquid peptonoids," etc., may often be serviceable. Other suitable additions to the dietary have been already referred to (page 223). Discretion in the administering of rich or concentrated foods is, however, very important, since the digestive function too often shares in the general enfeeblement, and may be easily deranged. Excessive or injudicious feeding may thus defeat the very object for which it is employed.

Alcoholic stimulants are required in most bad cases at this stage of the disease, and must in many cases be given freely. Their utility in the treatment of diphtheria, and its limitations, have been remarked upon on page 203 *et seq.*

Valuable assistance in promoting appetite and digestion and combatting the tendency to debility which attends the later stage of diphtheria and the period of convalescence, may be obtained from various tonics, especially the preparations and alkaloids of cinchona bark and nux vomica. Among standard preparations, the compound tincture of cinchona or the elixir or wine of calisaya, the elixir of pepsin, bismuth and strychnine, the elixir of the phosphates of iron, quinine and strychnine given in doses appropriate to the age, have obvious applications and utilities in this as in other diseases. The same in true of quinine in tonic doses of from one fourth of a grain to two grains three or four times a day. I have been enabled to obviate the important difficulty arising from its unpleasant bitterness in many cases of young children by the use of chocolate lozenges, each of which contains one grain of the tannate of quinine, and which are prepared by Caswell and Massey of this city. They are generally liked by children. Quinine may also in many cases be advantageously administered to young children in rectal suppositories. Two or three grains of the sulphate of quinine in five or six grains of the butter of cacao in each suppository is a convenient size. Their introduction is facilitated by the use of a small hard-rubber tube-and-piston depositor which is made for the purpose.

In conditions of extreme debility with accompanying progressive heart-failure, alcoholic stimulants given freely, but with careful regard to the limit of their tolerance by the stomach, are our most valuable resource. If the pulse is feeble and rapid or irregular, the tincture of digitalis may be given in small doses, the effect of which is to be carefully watched, and strychnine in small doses (from $\frac{1}{120}$ to $\frac{1}{30}$ of a grain) may be useful. Except in the case of very sensitive children, to whom the shock and fright caused by the operation may be injurious, the hypodermic administration of either of these remedies is to be preferred on account of its more prompt and certain effect. Freshly made coffee in teaspoonful doses may also be serviceable. Fresh beef-juice in similar doses may have a valuable stimulant effect. The predigested foods already referred to may be useful aids in maintaining nutrition. The great importance of the most abundant supply of fresh air should never be forgotten. If such bulky and unpleasant drugs as musk are employed in the case of children, their administration by enema is for obvious reasons to be preferred. The patient must be strictly kept in the recumbent posture and all unnecessary exertion and agitation avoided.

The mere fact of the occurrence of albuminuria does not ordinarily call for special treatment. Indeed, since its presence at this stage is usually the result of the irritation of the kidneys by the noxious products of the disease which have been absorbed into the general circulation, the indication which it furnishes is the continuance of the antiseptic and sustaining measures which have been already referred to.

The same indication remains equally in force in those graver forms of the affection in which the urine more or less suddenly becomes scanty and dark and of high specific gravity, and contains a large percentage of albumin with casts and blood-corpuscles, with accompanying febrile symptoms and marked evidences of uræmic poisoning; but the complication itself is so liable to be rapidly fatal, that prompt measures must be employed for its removal. These measures are the same as when nephritis occurs in other conditions, but the weakness and prostration of the patient often make their energetic employment impracticable. In cases in which this weakness and prostration are not too marked for its use to be admissible, and especially if the bowels are constipated, purgation by a single dose of from one to five grains of calomel or by doses of a quarter of a grain given in frequent succession or by a grain of calomel with from six to ten grains of compound jalap powder to a child from three to five years old, or to feebler patients a wineglassful of citrate of magnesia repeated every hour or two if necessary, will often have a promptly favorable effect.

Dry cups may be applied over the kidneys.

The mode of producing at once a revulsive and diaphoretic effect which I have found especially valuable in many cases of scarlatinal and diphtherial nephritis is to envelop the entire circumference of the loins and abdomen with a warm flax-seed poultice, which should be frequently renewed.

The use of the ordinary diaphoretic and diuretic drugs is often impracticable on account of the tendency to nausea and vomiting and the weakness of the patient. Digitalis may be given in the form of the infusion with citrate or acetate of potash if the stomach will retain it; but otherwise in the form of the tincture, of which a suitable dose may be added to other medicines or administered hypodermically.

Throughout the entire treatment of a case of diphtheria, great importance should be attached to maintaining the strictest cleanliness of the patient himself and all his surroundings. His clothing and the bed-linen should be frequently changed and thorough disinfection of all vessels and utensils practiced, as directed in the chapter on prophylaxis. The room should be frequently and thoroughly aired. In order that the patient may not take cold while this is being done the alternate use of two adjoining rooms, when practicable, is an advantage in the colder season of the year. In some persistent cases the removal of the patient to a fresh apartment has seemed to exert a favorable influence. When the climate and other circumstances make it practicable, the patient may sometimes be advantageously kept in the open air.

THE TREATMENT OF LARYNGEAL DIPHTHERIA.

Medical Treatment in reference to laryngeal diphtheria is (1) preventive and (2) mitigating or curative.

The liability of pharyngeal and nasal diphtheria to extend downward into the larynx, especially during the first few days, suggests the employment of measures in their early stage which may diminish that liability. These measures are:

1. Those which tend to moderate the intensity and check the spread of the primary affection, since that result diminishes

the probability of its extension into the larynx. These measures have already been referred to.

In the treatment of young children all irritating applications and unpleasant remedies which cause crying and struggling are especially contra-indicated, since in such crying and struggling the irritating drug or diphtheritic matter is liable to be drawn into the larynx and favor the extension of the disease thither.

2. Those which have a special tendency to prevent laryngeal implication.—These measures are the inhalation of unirritating antiseptic and astringent spray or vapor and also the internal use of certain drugs, especially mercurials and the oil of turpentine. These have also been referred to in connection with the treatment of pharyngeal diphtheria.

My own experience of the valuable effect of this use of the spray of carbolic acid and lime-water was stated in my first published report as follows: "Out of fully one hundred cases, including Dr. Darken's, in which the spray of carbolic acid and lime-water has been employed, there has been no instance of the subsequent occurrence of serious laryngeal complication, though in several of them it has been threatened by croupy cough, hoarseness and aphonia. That the inhalation of the spray has acted as a preventive in some of these is, I think, not improbable." Much subsequent experience of myself and others has confirmed me in this belief. The composition of this spray and the mode of using it have been stated on page 215.

In the case of children too young to take the spray, the inhalation of antiseptic vapor, especially that of the oil of turpentine, may be employed as a preventive.

Mitigating and Curative Measures.—The earliest possible recognition and treatment of laryngeal diphtheria is of great importance. The physician should pay careful attention to the slightest huskiness or hoarseness of the voice which may be its premonitory symptom. Many cases may doubtless be cut short or prevented from becoming severe when properly treated at their first slight beginnings, which would later defy all remedies.

When the symptoms of laryngeal diphtheria are present the measures to be employed depend somewhat upon their gravity and the rapidity with which they increase. In estimating at the outset the probability of their becoming severe, the fact elsewhere referred to may be remembered, that as a general (though not invariable) rule this probability is greater the earlier the laryngeal affection appears.

The remedies which may be employed comprise mercurials, solvent, antiseptic and astringent sprays and vapors, steam, expectorants and emetics.

The mildly solvent and antiphlogistic effect of the pleasant spray of carbolic acid and lime-water has been found sufficient in quite a number of cases of slight or moderate severity. In my first paper[1] I reported in detail a case of unquestionable laryngeal diphtheria accompanying pharyngeal diphtheria in a child of four years, in which very serious and constant dyspnœa in both acts, with marked depression over the clavicles with inspiration, continued for eleven days, but which finally recovered without operation under the very frequent use of this spray. I have since seen several almost as striking cases of recovery under the use of the same remedy.

The fact has been referred to that the solvent power of lime-water may be increased by adding to it another alkali, as, for instance, one per cent. of liquor potassæ, or bicarbonate of soda, but at the expense of making its frequent and continued use somewhat irritating to mucous membranes. Hence this method should be employed only where the necessity for a rapid solvent effect is urgent.

The testimony in favor of the utility of trypsin and papayotin as solvents of false membrane has been referred to, and the manner of employing them has been described on pages 168 and 169. The solution should be carefully prepared by rubbing the solvent in a mortar and, if necessary, afterward straining it, so that a fine spray may be used, and the solution should be of the most unirritating character, so as not to excite cough and dyspnœa.

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[1] Transactions of N. Y. Academy of Medicine, 1876, p. 210.

It must be remembered that the spray can effectively reach the interior of the larynx only by being carried thither by the inspired air. The atomizer should therefore be held at some little distance from the mouth (which must be widely opened and the tongue depressed if necessary) so that the atomized particles, having lost their first impetus, may be carried downward in the current of the breath. This necessitates some moistening of the face with the spray, but even quite young children, with proper management, soon become accustomed to it and tolerate it.

The same principle is applied in instruments called "nebulizers," or "vaporizing atomizers," which have recently been brought into use, by which the particles are so suspended in the air as to be readily carried into the air-passages by the breath. Liquids, in order to be "nebulized," require to be given a certain consistency by the addition of not less than one-eighth part of glycerine, or some similar substance. In the limited opportunities which I have as yet had for experimenting with these instruments I have not been able to satisfy myself that the amount of medicated fluid which can be so introduced is sufficient to be effective in the treatment of croup, but I think it not improbable that they may be found to have some utility. One of the best of them is the "vaporizing atomizer, No. 169," made by Codman and Shurtleff.

Though the use of the hand-atomizer has obvious advantages in point of convenience, yet in most cases in which it is practicable the application of spray together with warm vapor, by means of the steam-atomizer, is to be preferred.

Unfortunately, the impracticability of applying spray to very young children precludes its employment in a considerable proportion of our worst cases. The evils attending its application by force more than counterbalance its benefits. I have made many attempts to overcome this difficulty by various expedients, but never with satisfactory results.

In cases in which the efficient use of spray is impracticable, and in most cases which are serious or show a tendency to become so, the inhalation of steam should be resorted to. The most efficient method of doing this is the construction of a tent over the crib or bed with blankets and barrel-hoops or other supports. There should be an opening in one side of the tent for ventilation. The air within the tent may be kept saturated with warm vapor by means of a tube from a croup-kettle, which should be placed outside of it.

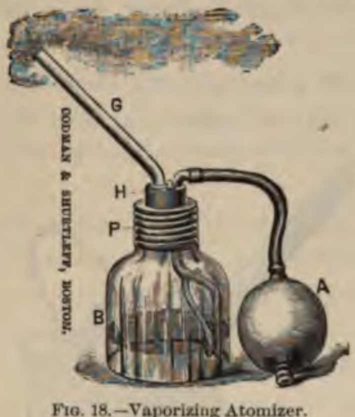

FIG. 18.—Vaporizing Atomizer.

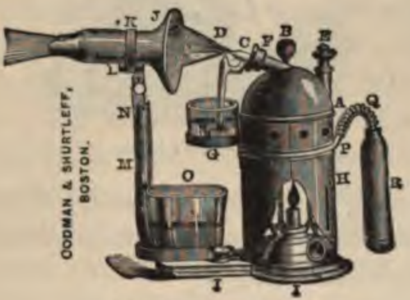

FIG. 19.—Steam Atomizer.

The air in the tent being thus maintained at an equable warmth, and draughts being excluded, the room can safely be ventilated by opening the window or otherwise, and the evil effect of the impairment of the air by the burning of the alcohol or other combustible employed, be in great measure obviated.

In the absence of a croup-kettle, an ordinary tea-kettle and a gas or oil-stove may be made to answer the purpose. When india-rubber tubing cannot be obtained, a substitute may be made with stiff paper or pasteboard surrounded with some fabric, as a roller-bandage.

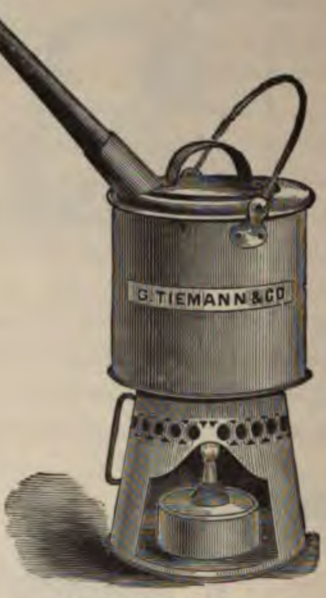

FIG. 20.—Croup-kettle.

Or a small room in which boiling water can be kept constantly running from the pipes, or in which steam-pipes can be tapped, may be utilized.

The solvent effect of lime on the false membrane may be additionally obtained by putting pieces of quick-lime into the water in the croup-kettle every hour or two. It should always be remembered that the boiling of lime-water for this purpose, which is often recommended, is useless.

The vapor may be made the vehicle of various drugs for their antiseptic or specific effect. The most valuable of these is the oil of turpentine. This may be added, a tablespoonful at a time, to the water in the croup-kettle every hour or two, or it may be volatilized in the air of the room by the method of Dr. Delthil, described on page 197. Its good effect may perhaps be aided by adding a teaspoonful or two of the oil of eucalyptus.

The abundant evidence of the special utility of the bichloride of mercury in the treatment of this form of diphtheria, and the importance of its early employment, have been already referred to. When the drug is given to avert threatened laryngeal stenosis, the indication is, of course, to bring the system of the patient as rapidly under its influence as is consistent with safety. In such circumstances it is important to know that the tolerance of it is, in many children, remarkably great. Dr. Jacobi states[1] that "a baby a year old may take one-half grain every day many days in succession with very little if any intestinal disorder and with no stomatitis," if it be given in proper dilution. This is equivalent to one forty-eighth of a grain every hour. Dr. O'Dwyer, who has employed this remedy in many cases of croup, and regards it as very valuable, begins with about one eightieth of a grain at that age, and gradually increases to the dose mentioned by Dr. Jacobi, if the case threatens to run a rapid course. He very seldom begins at any age with more than one fiftieth of a grain hourly, and increases or not according to the progress of the case. He also attaches much importance to proper dilution, having known one fiftieth of a grain dissolved in two drachms of water to give rise to severe pains in the stomach, which did not recur when the dilution was increased to half an ounce. He has yet to see any serious gastric or intestinal disturbance, or more than the slightest amount of stomatitis, from the sublimate administered in this manner, even when continued so long as a week. A moderate looseness of the bowels is, according to his experience, easily controlled by the addition of a mild opiate, but directions should always be left with the attendant to suspend the medicine on the occurrence of any severe diarrhœa or much pain in the stomach or bowels.

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[1] Loc. cit.

The advantage, when large doses are being administered, of giving them in half the quantity every half-hour, has been referred to on page 221.

The administration of mercury by inunction, by hypodermic injection, and by volatilization and inhalation, has been referred to on pages 177, and 178.

The internal administration of the oil of turpentine has also been referred to on pages 195 and 222.

Emetics have a well established utility in the treatment of croup, whether catarrhal or diphtheritic; but they should be used with discretion—not too often, nor usually in the later stages of the disease, nor ever in conditions of marked weakness, systemic infection or cyanosis. They are beneficial mainly by their expectorant effect, producing increased secretion of mucus and the expectoration of that which has accumulated, and sometimes causing the throwing off of membrane which is only loosely attached. They usually give temporary relief, at least.

While the syrup of ipecacuanha, or of ipecacuanha and squills, in doses of half a teaspoonful to a teaspoonful, or sulphate of copper in doses of two to five grains, repeated, if necessary, in fifteen minutes, will render excellent service in many cases, the yellow sulphate of mercury is usually to be preferred as being most reliable, prompt and thorough in its action. The dose is from three to five grains. To much previously published testimony to the especial utility of this emetic I am permitted to add the following statement by Dr. O'Dwyer: "In what may be called sthenic cases, when the dyspnœa becomes urgent and abiding, or, in other words, when it is time to operate, prompt vigorous emesis, such as is produced by the yellow sulphate of mercury, often gives marked relief, which sometimes lasts long enough to render a repetition of the vomiting safe, if stimulants and nourishment be administered in the interim. By this means I have succeeded in getting a good many cases through, especially those that had been placed on the bichloride treatment at the commencement of the disease, that would otherwise have required intubation."

In asphyxia emetics usually fail to act. In this condition it is said that the emetic action of apomorphia is not interfered with. It should be freshly prepared. Its hypodermic administration in doses not to exceed one centigramme is recommended by Muñoz.[1] In this condition, however, it need hardly be said that not an emetic, but intubation or tracheotomy, is the remedy which should be employed.

In those cases in which a frequent, harsh and painful cough is accompanied with recurrent paroxysmal dyspnœa, an opiate is useful—as, for instance, Dover's powder or its liquid equivalent, the tinct. ipecacuanhæ et opii of the Pharmacopœia, in doses proportionate to the age and the amount of pain and irritation. The good effect of the remedy may be aided by the application of warm flax-seed poultices, to which a small proportion of mustard has been added.

The remarks made as to the importance and the methods of maintaining nutrition in other forms of diphtheria are equally applicable in reference to this one. In proportion as the strength is taxed by the persistent dyspnœa, and in proportion as the amount of nutritious food which the patient will take is diminished, the giving of alcoholic stimulants becomes the more necessary, and is consequently required in most cases of any severity or duration. After tracheotomy or intubation, this necessity usually becomes, from the latter of the reasons referred to, even more imperative.

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[1] El Prog. Ginecol., July 10, 1887.

Laryngeal diphtheria may doubtless be prevented or cured by the early employment of the measures which have now been referred to, in a considerable proportion of cases; but since its initial symptoms, such as huskiness of the voice and croupy cough, even when they occur in connection with other forms of the disease, can by no means be regarded as pathognomonic signs of a pseudo-membranous affection of the larynx, these results cannot be statistically estimated. It must be admitted that in a large proportion of all cases of unquestionable laryngeal diphtheria, medical treatment alone is inadequate to prevent a fatal termination. This proportion has been estimated by Morell Mackenzie[1] at ninety per cent. Sanné[2] states that in 2809 cases of croup which have been entered at the Hôpital Sainte Eugénie, 240, that is 1 in 13, have recovered without operation.

TRACHEOTOMY.

When the respiration is so seriously interfered with in laryngeal diphtheria that asphyxia is imminent, operative interference is usually the only resource by which the life of the patient can be saved. There can be no doubt that intubation will in the future, to a greater or less extent, take the place of tracheotomy in fulfilling this indication: but since that operation, as it is now practised, with its general and special indications, will be subsequently treated of by its inventor, Dr. Joseph O'Dwyer, I shall confine my remarks to tracheotomy.

The utility of tracheotomy as a means of saving life is, in a general sense, sufficiently illustrated by comparing with the estimate just quoted of the ratio of recoveries in cases of membranous croup not operated upon, the following statistics of the recoveries in all available reported cases[3] in which tracheotomy has been performed previous to 1887, as compiled in an interesting and instructive paper by Drs. Lovett and Munro:[1]

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[1] Op. cit., p. 88.

[2] Op. cit., p. 80.

	Total.	Recovered.	Died.	Per Cent Recovered.
German authors	5795	1851	3944	31
German hospitals	3063	939	2124	30
British authors	433	138	295	31
French authors	9242	2242	6834	24
Various countries	1993	657	1336	32
American authors	1327	308	1019	23
	21,853	6135	15,552	28

Tracheotomy has, in many considerable series of cases, been attended with a much larger proportion of recoveries, as is illustrated in the following examples:

	Operations	Recoveries	Per cent. of Recoveries
Surgical Clinic in Konigsberg, 1878–1882, (Plenio[2])	123	60	$48\frac{7}{10}$
Tracheotomies by H. Ranke,[3] Munich, April 1, 1878, to Sept. 1, 1885. .	54	34	63
Tracheotomies by A. Caselli[4] . .	132	82	$62\frac{2}{10}$
Ibid (with improved instruments) .	18	13	$72\frac{3}{10}$

The results of tracheotomy differ widely according to a great variety of circumstances, of which the following are especially important:

1. *The methods and skill employed in the operation and the after-treatment.*

2. *The age of the patient.*—The results of tracheotomy are very unfavorable in infants, and in older children improve in

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[1] "A Consideration of the Results in 327 Cases of Tracheotomy Performed at the Boston City Hospital from 1864 to 1887; by Robert W. Lovett, M.D., and John C. Munro, M.D.," American Journal of the Medical Sciences, 1887, vol. xciv., p. 160.

[2] Jahrb. f. Kinderh., Bd. xxii., H. 4.

[3] Jahrb. f. Kinderh., Bd. xxiv., p. 225.

[4] Gaz. Med. Ital. Lomb., 1887, p. 198.

proportion to the age. Dr. Gustav. Chagin[1] has collected the statistics of 9[illegible] operations in infants, of whom only 15 per cent. recovered.

M. Sanné[2] thus states the results of tracheotomies at the Hôpital Sainte Eugénie according to the age of the patients:

Age.	Cases.	Recoveries.	Per cent.
1 to 2 years . .	[illegible]	88	13.6
3 " 5 " . . .	[illegible]	[illegible]	21.9
6 " 10 " . . .	[illegible]	[illegible]	37.8
11 " 15 " . . .	[illegible]	9	32.3

Dr. H. Settegast[3] has tabulated the results of tracheotomies in the Krankenhause Bethanien [illegible] to [illegible] as follows:

Age.	Cases.	Recoveries.	Per cent.
2 to 3 years . . .	[illegible]	[illegible]	[illegible]
3 " 4 " . . .	[illegible]	[illegible]	[illegible]
4 " 5 " . . .	[illegible]	[illegible]	[illegible]
[illegible] " [illegible] " . . .	[illegible]	[illegible]	[illegible]
[illegible] " [illegible] " . . .	[illegible]	[illegible]	[illegible]
[illegible] " [illegible] " . . .	[illegible]	[illegible]	[illegible]
[illegible] " [illegible] " . . .	[illegible]	[illegible]	[illegible]
[illegible] " [illegible] " . . .	[illegible]	[illegible]	[illegible]

3. *[illegible] of the disease.*—This has been remarked by most writers on the subject. Lovett and M[illegible] state that the tracheotomy death-rate at the Boston City Hospital from [illegible] to [illegible] inclusive, varied by the month in the closest correspondence to the mortality per cent. of diphtheria for the same time in the whole city of Boston.

4. *The season of the year.*—The writers just quoted from state that during the same five years ([illegible]) but twenty per cent. recovered of those operated upon in December, January, February and March,[illegible] while from the other months the

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[illegible]

recovery rate rises until July, when about sixty per cent. of all cases operated upon get well."

M. Sanné states that the results of all the tracheotomies at the Sainte Eugénie up to 1876 give the following ratios of recoveries: for June, 1 to 3.31; for August, 1 to 3.56; for November, 1 to 7.19; for December, 1 to 6.18; and for January, 1 to 5.04.

5. *The stage of the disease.*—It is a well-established fact that the prospect of the successful result of tracheotomy is the greater the earlier it is performed after the nature of the disease requiring it is recognized. This is further illustrated by the following figures in the article of Lovett and Munro from which I have previously quoted:

The time is reckoned from the beginning of obstructed respiration.

Day of Operation.	Cases.	Recoveries.	Per cent.
1	123	40	32.5
2	86	24	28.0
3	33	8	25.3
4	7	1	14.0

6. *The condition of the patient.*—The most favorable results from tracheotomy may be expected when the previous health of the patient has been good and the disease is primary and uncomplicated. The prospect of success is generally bad in secondary diphtheria, and when the laryngeal affection accompanies a malignant or septic form of diphtheria, or is attended with pseudo-membranous bronchitis, broncho-pneumonia or other grave complications.

These unfavorable conditions are regarded by some as contra-indications to the operation. This may doubtless insure the avoidance of many bad results. Dr. J. Lewis Smith states that a surgeon of this city (Dr. A. R. Robinson) who carefully selects his cases, operates early and deliberately, and supervises by frequent visits the after-management, has saved since 1880 eleven in thirteen consecutive cases of undoubted membranous croup. Yet since the primary object of tracheotomy is simply to relieve asphyxia, and since there have been instances of subsequent recovery under the most unfavorable conditions, it would seem to be properly indicated in all cases in which it is probable that death by suffocation would take place without it.

Another indication for the operation is often urged, namely, that even if it fails to save life it will secure euthanasia. The statements of Lovett and Munro on this point are important. In 232 fatal cases the proportion of deaths from the extension of the disease downward into the trachea and bronchi to those from septicæmia were as follows:

	Extension.		Septicæmia.
In all the fatal cases	1⅔	to	1
In children under 2 years	3⅓	to	1
In children from 2 to 10 years	1⅓	to	1

The writers remark, "It will be seen from this that young children are particularly liable to that distressing cause of death, extension of the process to the bronchi. When this happens there is no euthanasia; death is the slowest and most painful of suffocations, and only when septicæmia to the point of stupefaction is present at the same time does the child escape a horrible amount of suffering."

In favor of early tracheotomy the unquestionable fact is urged that, in the words of Trousseau, "the earlier the operation is performed the greater are the chances of success," and that the danger of the unexpectedly rapid occurrence of fatal asphyxia is thereby avoided. On the other hand it is argued that in a certain proportion of cases recovery does take place without operation, and that when the patient can be vigilantly watched and the operator can be promptly summoned in case of need, medical treatment should first be tried, and the operation performed only when asphyxia is imminent. This question must be decided in each particular case by a due consideration of the circumstances attending it. That an error in the direction of unnecessary earliness is a safer one than that of too great procrastination, has been illustrated in many melancholy instances. Now that the alternative of intubation is available, many of the perplexities which formerly beset the physician in making this decision are happily removed.

Another indication for the early performance of tracheotomy has lately been suggested which will, in my opinion, assume greater prominence the more our knowledge of the pathology and treatment of the disease is perfected. Mr. W. W. Cheyne,[1] in view of the pathological fact that "in almost all cases the membrane appears first in the larynx and spreads thence continuously down the trachea," proposes that tracheotomy be performed with the greatest possible antiseptic precautions as soon as it is evident that there is a membranous affection of the larynx, with the object of preventing, by suitable disinfectant treatment applied through the tracheal opening to the mucous membrane of the larynx and trachea, the downward spread of the diphtheritic process. In order to accomplish this it is necessary that the trachea be opened more freely than is usual, so that through the opening the interior of the trachea may be inspected and antiseptic applications may be made upward into the larynx and over the mucous membrane of the trachea. The details of one case are given, in which by removing the advancing membrane in the trachea by dissecting forceps and sponging the surface with a 1 in 500 solution of bichloride of mercury, its progress was arrested.

A different application of the same principle is reported by Roser.[2] At the Marburg surgical clinic the cannula used in tracheotomy has been surrounded with an antiseptic tampon prepared in the following manner: The cannula is wound with a muslin bandage which has first been moistened with a solution of sublimate. While it is still moist it is sprinkled with powdered iodoform. This, when dry, forms a crust which adheres to the cannula. When the instrument thus prepared is inserted into the trachea, the muslin swells again and forms a tampon. Its calibre must be such as to exactly fill the trachea. Thus is constituted an antiseptic barrier which the advancing diphtheritic process cannot pass. It is left in the trachea two days, and is then replaced by a fresh one, which is left until the fifth day. Of forty-seven tracheotomized diphtheritic patients thus treated during the past three years there have been fifty-three per cent. of recoveries.

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[1] British Medical Journal, March 5, 1887, p. 505.

[2] Revue Mens. des Mal. de l'Enf., June, 1888.

THE OPERATION.

The high operation, in which the opening is made into the upper portion of the trachea, is now generally preferred as the easier, safer and more expeditious one.

The patient, wrapped in a blanket, should be laid on his back on a table so placed that his left side shall be toward the window or artificial light, and his neck should be extended by having placed under it an ordinary wine-bottle wrapped in a napkin.

Then chloroform should be given, unless the patient is already asphyxiated or narcotized by septic-poisoning.

The operator should stand to the right of the patient.

An incision through the skin should be made downward from the cricoid cartilage exactly in the median line for one and one-half inches, or more, if necessary.

The tissues should then, under ordinary circumstances, be carefully and deliberately dissected down to the trachea, the edges of the wound being separated by retractors, and vessels being avoided and put aside.

If the isthmus of the thyroid body is unusually high, it may be displaced downward, the muscular and ligamentous bands by which it is attached to the hyoid bone and thyroid cartilage above having first been divided with curved scissors on either side of the incision opposite the first ring of the trachea.[1] "But in the immense majority of cases," says Sanné, "this portion of the gland is only a thin strip which passes unnoticed."

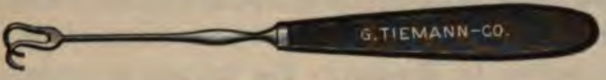

FIG. 21.—Pilcher's Retractor.

All bleeding should be arrested by the forceps, clamps or ligature before the trachea is opened. Then the point of the knife should be carried into the trachea, and the two or three upper rings divided.

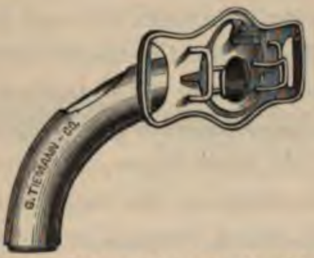

FIG. 22.—Double Trachea Tube. Movable Plate. Silver.

The opening of the trachea is announced by the escape of air. Fragments of false membrane sometimes present themselves at the opening and are coughed out, or may be extracted by forceps. It is often advisable, before introducing the cannula, to excite coughing by inserting a feather downward into the trachea, that blood, mucus or fragments of false membrane may be expelled.

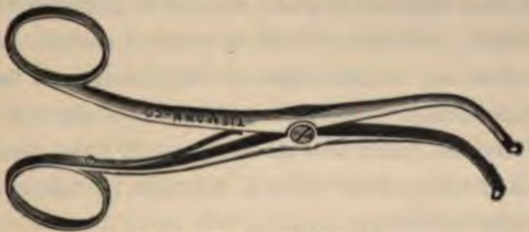

FIG. 23.—Trousseau's Dilator.

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[1] Dr. J. A. Wyeth: "A Text Book on Surgery," p. 453.

The cannula may be introduced by using the nail of the left index-finger as a guide into the tracheal incision, or by the aid of the dilator. Difficulties in doing this should be overcome by repeated gentle efforts, but never by force.

A rapid operation is practiced and described by Sanné,[1] and advocated by Renault.[2] The trachea is grasped by its sides at the level of the thyroid cartilage, between the thumb and middle fingers of the left hand, while the index-finger of that hand finds the cricoid cartilage, the finger-nail being placed upon its lower border. This hand must not be removed until the cannula has been inserted.

The incision having been made through the skin downward from the point indicated by the finger-nail, a few additional strokes of the knife bring one to the trachea. The bleeding is not usually of any importance in this situation. The trachea, being felt by the left index-finger, is punctured and incised. Then the cannula is taken in the right hand, and, guided by the left index-finger, which remains in the wound, is inserted into the tracheal opening.

In this operation the prompt insertion of the cannula is relied upon to arrest the hæmorrhage; but this promptness requires that the operator be expert in tracheotomy. Except when the rapid completion of the operation is especially called for, the more deliberate method should be preferred.

To prevent infection of the wound it should be sponged with an antiseptic solution before the trachea is incised, and at the completion of the operation should be dusted with iodoform and dressed with two thicknesses of linen, which should be moistened every hour with a solution of the bichloride of mercury (one in two thousand).

In the after-treatment it is very important that the air of the room be kept at a proper and uniform degree of warmth and moisture. The diffusion through it of unirritating antiseptic vapors, such as have already been referred to (page 197), is a valuable addition.

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[1] Op. cit., p. 522.

[2] "Manuel de Tracheotomie," by Dr. P. Renault; G. Steinheil, éditeur.

The tube must be vigilantly and intelligently watched. Whenever it becomes obstructed by the discharges or fragments of false membrane, the inner tube must be withdrawn and cleansed.

The use of mild antiseptic atomized solutions administered with the inspired air through the tube may be practiced. The spray of carbolic acid and lime-water (page 215) is especially appropriate. Mild solutions of borax or boracic acid may be similarly used, or insufflations of iodoform, as referred to on page 186.

If there is false membrane below the tube, the frequent introduction of solutions of trypsin or papayotin in spray, or by means of a slender quill, may be resorted to.

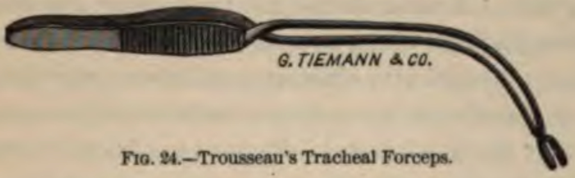

FIG. 24.—Trousseau's Tracheal Forceps.

The dislodgment and removal of obstructing membrane below the tube has in some cases been effected by means of forceps or the croup-brush, or an instrument which is made by surrounding the end of a soft flexible urethral catheter with a ring five or six millimetres in diameter.[1]

After the expiration of twenty-four hours from the operation, and at such subsequent intervals as are requisite, the cannula should be removed to facilitate the ejection of accumulated matter from the trachea and the inspection and dressing of the wound.

When air begins to pass through the larynx, the cannula may be removed for a short time, which may be repeated and the time extended as the patient becomes more able to d pense with it, until it is finally removed altogether. The length of time from the first insertion to the final removal of the cannula varies very greatly in different cases. In a large majority of all cases this period does not exceed eight days, but in some instances it is several months or even years.

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[1] Roser, Loc. cit.

THE TREATMENT OF DIPHTHERITIC PARALYSIS.

Since diphtheritic paralysis is due to the immediate or remote effect upon the nervous system of the diphtheritic poison, and since it usually disappears *pari passu* with the accompanying anæmia, the measures especially indicated in its treatment are those which tend to counteract the former and remove the latter. These are rest, fresh air and a restorative regimen. Among drugs the tincture of the chloride of iron, the actions of which as a hæmic restorative, a stimulant tonic, and an eminently efficient antidote to the debilitating poison of diphtheria have been elsewhere referred to, is incomparably the most useful. My own experience in the treatment of quite a large number of cases has furnished a striking illustration of this fact. The medicinal treatment of these cases has invariably consisted mainly in the continued frequent administration of iron by one of the formulæ given on page 220. The rapidity with which the paralysis has disappeared, even in some grave cases, has been remarkable.

The tendency of the affection, in the great majority of cases, to early recovery, and, even in the more severe and persistent ones, to an ultimate restoration of function, which is often rapid when it has once commenced, would naturally lead to the attributing of special curative virtues to whatever drug or method of treatment might chance to have been employed. Hence strychnine and electricity have received a large meed of credit for many recoveries.

With regard to the beneficial effect of electricity experience and opinions differ. Dr. A. D. Rockwell, of this city, informs me that according to his experience in a considerable number of cases it has seemed to shorten the duration of the affection. Seeligmüller[1] attaches much importance to its use. The constant current should be employed. When the velum palati is affected the positive pole should be placed on the nucha, the negative one under the inferior maxilla; in ocular paralysis, the positive pole on the nucha, and the negative in the vicinity of the paralyzed muscles; in paralysis of the lower extremities, the positive over the lumbar region and the negative over the nerves which are to be excited. Gowers[2] recommends the use, in severe cases, of the voltaic current, slowly interrupted, in such strength, if possible, as will cause the affected muscles to contract; but in the case of children the use of a weaker current is far preferable to the exciting of distress and alarm by a stronger one, "since the utmost good that electricity can do is very small compared with the harmful influence of a daily fright." Gentle friction or massage over the affected region often seems to be beneficial, but any violent or fatiguing procedures of the kind are strongly contra-indicated.

Strychnine in small doses may doubtless render valuable service in aiding to restore the tone and activity of the digestive organs. Gowers[3] says that while it sometimes seems to be of service "it is certainly powerless to neutralize the morbid process in its early stages, and seems to be without influence on the spread of the disease. Moreover it is not wise to give large doses of a drug that stimulates the nerve-cells so powerfully." In cases of extreme paralysis of the muscles of deglutition and respiration, its hypodermic use has seemed to be beneficial. Reinard,[4] reports a favorable result of the daily injection of one milligramme ($\frac{1}{65}$ grain) of sulphate of strychnia in a desperate case of general diphtheritic paralysis involving the muscles of respiration. After the first injection respiration was easier, and a cure was effected in fifteen days.

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[1] E. Adler: Med. Chirurg. Rundschau, No. 4, 1886.

[2] Diseases of the Nervous System, p. 1236.

[3] Loc. cit.

[4] Deutsche Med. Wochenschrift, 1885, No. 9.

Dr. W. H. Thomson[1] has found the recourse to strychnia and electricity very disappointing; but he states that topical irritants seem occasionally to be quite effective. In palatine and pharyngeal paralysis he brushes the parts every few hours with a paste of black pepper and honey, with a view to awakening their lost reflex excitability. In paralysis of the limbs, trunk, etc., he has the parts enveloped twice a day in a pack of infusion of capsicum of the strength of a drachm of the powder to a pint of boiling water, the application to last from ten to twenty minutes.

The difficulty of deglutition is, in some cases, one of the most serious complications to overcome. When the paralysis is in the palate, solid or semi-solid food can be swallowed; but when the muscles of the pharynx and upper part of the larynx are affected, with insensibility of the epiglottis, the administering of food by the ordinary means becomes dangerous or impossible from its tendency to enter the larynx. In such cases resort must be had to the œsophageal tube or a large catheter or to rectal enemas. The necessity of giving nourishment by one or both of these methods is imperative in order to avoid the danger of exhaustion.

In the case of serious dyspnœa and danger of suffocation from the accumulation of mucus in the bronchial tubes in paralysis of the respiratory muscles, resort to artificial respiration may tide the patient over a dangerous emergency. Dr. W. H. Thomson suggests that in such cases the treatment which is so successful in cases of bronchial palsy be tried. "The patient should be let down on his hands from the bed with his head down, and encouraged to cough, and frequently a short recourse to this measure will result in expelling a quantity of suffocative fluids from the trachea with great relief to the respiration for some time." In such cases the application of the faradic current to the skin of the back of the chest with a view to the reflex stimulation of the respiratory centre has been found promptly serviceable by Duchenne.[1]

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[1] Medical News, June 4, 1888, p. 635.

For the sudden heart-failure which sometimes occurs in the first or second week of diphtheria, all remedies are too often unavailing. The patient must be kept strictly quiet in the recumbent position. A hot poultice, over which mustard has been dusted, should be applied over the cardiac region. Warm stimulating applications and rubbing should be kept up over the extremities. Brandy or whiskey should at once be given hypodermically, and small doses of digitalis may be given in the same manner. Faradization over the cardiac region is recommended by Duchenne as a powerful cardiac stimulant under such circumstances. Ammonia, camphor, musk, and other stimulants are recommended, but are of doubtful utility, especially as the tolerance of the stomach for drugs and food is usually very limited, and should be carefully economized. I have seen small doses of coffee and of beef-juice, and champagne given pretty freely, well retained and beneficial. By the judicious use of the measures referred to, the patient may sometimes be carried through an alarming emergency, though too often their good effect is only transient.

The milder forms of cardiac paralysis, which usually appear at a later period in connection with other forms of diphtheritic palsy, may be treated by the remedies which have been already referred to as appropriate for that condition, with the addition of small doses of digitalis; and the special danger of any violent exertion or even of suddenly rising from the recumbent position should always be borne in mind.

DIPHTHERITIC CONJUNCTIVITIS.

In the treatment of diphtheritic conjunctivitis, the following measures are indicated:

In the first stage, small pieces of lint, cooled on a block of ice, should be laid over the eye and changed every minute or two; in the second stage warm or moderately cold applications should be used according to the sensations of the patient.

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[1] "Selections from the Works of Duchenne," by Dr. Poore, p. 356.

Antiseptic solutions, such as mercuric bichloride (1 in 8000), carbolic acid (30 minims to the pint), or boric acid (one to four drachms to the pint) should be dropped into the eye hourly. The most thorough cleanliness must also be maintained by irrigation with the same or weaker solutions, used warm or tepid. Dusting iodoform into the eye has been recommended.

In the third stage astringent solutions, as of nitrate of silver (5—10 grains to the ounce), or tannin (20 grains to the ounce) applied once or twice a day are useful.

In case of great pressure upon the cornea from the swelling of the eyelid, canthoplasty should be performed.

The greatest care must be taken to prevent the infection of the sound eye, by protecting it with an impermeable covering.

CUTANEOUS DIPHTHERIA.

The ordinary forms of cutaneous diphtheria usually recover rapidly when simply kept clean, dusted over with iodoform, and covered with lint, which is kept moistened with a mild antiseptic solution, as of bichloride or carbolic acid.

The more serious forms of wound-diphtheria, which sometimes occur in hospitals, should be treated on the same principles as hospital gangrene. The false membrane and necrosed tissues should first be destroyed or removed. This may be done by means of the galvano-cautery; or they may be dissected away as completely as possible, after which bromine is applied, and then the wound is covered with iodoform, and dressed antiseptically.

APPENDIX.

A RECENT contribution to the etiology of diphtheria[1] by MM. Roux and Yersin of the Pasteur Institute, Paris, has reached me too late for its statements to be incorporated into the chapter on that subject; but those statements are, *prima facie,* so important in view of the corroboration which they furnish to previous observations which have been referred to in that chapter, that a summary of them is here appended.

MM. Roux and Yersin have found the bacillus of Klebs and Loeffler (described on page 37) in the false membranes in every one of fifteen cases of human diphtheria examined by them. They have isolated it in pure cultures by methods nearly identical with those of Loeffler. They state that it is freely reproduced in the absence of air, but less energetically than in its presence. It maintains its vitality for a long time in nutritive media, having been thus preserved for more than six months in tubes hermetically sealed.

The cultures made by the authors have been more active than were those of Loeffler, the effect of their inoculation into animals having been more uniform and more fatal, but in most other respects the results of their experiments have been identical with those described by him.

In inoculations of the culture upon mucous membranes they have found it necessary to first excoriate them; merely smearing it over healthy mucous membranes produces no result.

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[1] "Contribution à l'Étude de la Diphthérie, par E. Roux et A. Yersin," Annales de l'Institut Pasteur, Decembre, 1888.

The affection produced by inoculations in the trachea of the rabbit strikingly recalls the features of human croup—congestion of the mucous membrane, false membrane, œdematous swelling of the tissues and the glands of the neck, dyspnœa, stridulous breathing, asphyxia.

Injections of the culture beneath the skin of pigeons, rabbits and guinea-pigs, in sufficient quantity, caused their death in from thirty-six hours to five days, the period varying according to the susceptibility of the animal and the amount of the culture introduced. In the rabbit the autopsy showed at the point of inoculation an extensive œdema infiltrating a tissue indurated with hæmorrhagic points, swelling of glands, congestion of the omentum and mesentery, with small ecchymoses along the vessels; the liver friable, of a yellow tint, and the seat of a grayish degeneration. In guinea-pigs, which are the most susceptible to the action of the bacillus of diphtheria, the post-mortem lesions consisted in a grayish membranous coating at the point of inoculation, a gelatinous œdema of greater or less extent, a general dilatation of blood-vessels, congestion of glands and internal organs, especially of the suprarenal capsules, the pleuræ being often filled with a serous effusion and the pulmonary tissue sometimes in a state of splenization.

After intravenous injections in rabbits of one cubic centimetre of the culture, the animals usually died within sixty hours. The lesions found at the autopsy were a general congestion of the abdominal organs, dilatation of vessels, swelling of glands, acute nephritis, and the hepatic degeneration already referred to.

Is the bacillus from a very infectious case of human diphtheria more active than those from a benign case? Without being able to definitively answer that question, the authors state that a culture from the false membrane of a very benign case was found to be very active when inoculated into rabbits.

From the results of a large number of careful examinations the authors confirm the observations of Loeffler and others that the bacillus of diphtheria is to be found only in the false membranes and at the point of inoculation, and never in the blood or the organs, except transiently and accidentally (as, for instance, within a few hours after intravenous injections) and it is never reproduced there. In rabbits, after intravenous injection, the microbes had entirely disappeared within sixteen hours; yet the malady pursued its course, and the rabbits died in from thirty to thirty-six hours.

Diphtheritic Paralysis.—MM. Roux and Yersin have been the first to succeed in experimentally producing diphtheritic paralysis in animals. They have produced this result by intratracheal, subcutaneous or intravenous inoculations in numerous instances in which the animal did not succumb to a too rapid intoxication. Paralysis commenced in a pigeon three weeks after inoculation in the pharynx, when the false membranes had disappeared and the animal seemed to have completely recovered. The powerlessness of the feet and the wings was almost complete. When this muscular feebleness had continued for a week there was an amelioration in the movements of the feet, but the rabbit died five weeks after the inoculation. The autopsy showed no lesion, either of the articulations or of the nervous system, to account for the symptoms. Many of the localizations which occur in human diphtheritic paralysis were observed in various cases. In rabbits the first invasion of the paralysis was usually by the posterior extremities, and it progressed so rapidly that in a day or two it affected the whole body, and the animal died by failure of the respiration or of the heart's action. In rarer instances the paralysis in rabbits began in the muscles of the neck, the rabbit being unable to raise the head from the ground, or in the larynx, causing hoarseness of the voice. The authors remark: "The occurrence of these paralyses, following the introduction of the microbe of Klebs and Loeffler, completes the resemblance of the experimental disease to the natural malady, and establishes with certainty the specific rôle of that bacillus."

The Diphtheritic Poison.—The truth of the conclusion which has been reached by Loeffler and others that the bacillus exerts its morbific effect by means of an active poison which is produced by the microbe at the seat of the local affection and thence diffused through the system, has also been demonstrated by the experiments of MM. Roux and Yersin. They have done this, not by isolating the poison, but by pursuing the following method: Filtering through porcelain a pure culture of the bacillus in bouillon of veal, which is seven days' old, all the microbes are retained by the filter, and the liquid obtained is perfectly limpid and slightly acid. If this liquid is introduced in doses of from two to four cubic centimetres beneath the skin of animals, it does not make them ill. If, however, a dose of 35 c.c. is injected into the peritoneal cavity of a guinea-pig or the veins of a rabbit, the animal for a time appears to be well, but after two or three days becomes inquiet and trembles, is increasingly feeble, is seized with a profuse diarrhœa, the respiration becomes labored and irregular, he is no longer able to move, and dies without convulsions five or six hours after the commencement of the symptoms. A guinea-pig which has received 35 c.c. of the same liquid into the peritoneum dies after about ten hours, having experienced great difficulty in respiration. The autopsy shows the characteristic congestion of the viscera, especially the kidneys and the suprarenal capsules, and there is often a pleuritic effusion. If quantities of the filtered liquid, varying from ⅕ c.c. to 2 c.c., are introduced under the skin of guinea-pigs, they are presently seized with the same symptoms, and die in the same manner, as those which have been inoculated with the living culture, after periods varying from twenty-four hours to three days, according to the dose administered. The lesions are also the same, except that false membrane is wanting. There is the same œdema, the same indurated tissue at the point of inoculation, the same hæmorrhagic congestion of the organs, especially of the kidneys and the suprarenal capsules, and the same pleuritic effusion. In short, "the malady—both symptoms and lesions—is communicated as certainly by the injection of the filtered poison as by the inoculation of the bacillus."

The symptoms produced by the inoculations of the filtered fluid, vary according to the dose of the poison contained in the culture. In the case of a guinea-pig dyspnœa began on the fifth day, and continued for a week; the respiration was diaphragmatic and jerking. When the animal was obliged to run, the oppression became so great that he fell, almost asphyxiated. These symptoms amended gradually, and he recovered. In rabbits the same commencement of the paralysis in the posterior extremities and its rapidly fatal generalization, which has been already described, occurred. When the intoxication is less severe, the paralysis may remain for some time limited to a group of muscles.

Animals which, like rats and mice, are not affected by the inoculation of the bacilli, show the same resistance to the filtered poison.

Is the diphtheritic poison an alkaloid or a diastase? While not yet prepared to definitively answer that question, the authors state that the activity of the toxic matter is greatly diminished by heat, and also by exposure to the air—circumstances which favor the latter hypothesis.

The first part of a study of the etiology of diphtheria[1] by Dr. T. M. Prudden, which is very important both from the completeness and precision of its methods of investigation and the definiteness of its results, appears just as this work is going to press. It consists of bacterial examinations, morphological and by cultures, in twenty-four fatal cases of diphtheria. In most of the morphological examinations micrococci, usually in large numbers, were found in all parts of the false membranes, including their deeper layers, in the necrosed epithelium, in some instances in the lymph-spaces of the mucosa and submucosa, and in one instance extending deeply into the submucous tissues, accompanied, when abundant, with necrosis. The cocci in the false membrane were accompanied by other bacteria, among which in some of the cases, are mentioned various forms of bacilli; but these are usually described as few, scattering, and limited to the more superficial portions of the false membranes. In two exceptional cases micrococci were wanting, and bacilli were numerous.

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[1] "On the Etiology of Diphtheria," by T. Mitchell Prudden, M.D., American Journal of the Medical Sciences, April, 1889.

In most of the cultures from the false membranes streptococci, usually in great numbers, and, in some instances, in nearly pure cultures, appeared. The other bacteria, including the various forms of bacilli, were not uniformly present and were, in most cases, in much smaller numbers. In the two exceptional instances already referred to (in which the larynx and trachea were lined with dense firm false membrane, but there was no false membrane in the pharynx) no colonies of streptococci appeared in the cultures, but "short, stout, round-end bacilli" were numerous. In seven cases, cultures of streptococci, in most instances pure, were developed from one or more of the internal organs, namely the kidneys, the spleen, the lungs and the liver.

These observations, as is remarked by the author, seem to point to the importance of the streptococcus. A study by him of its characters and life-history will be subsequently published.

INTUBATION IN CROUP

AND OTHER

ACUTE AND CHRONIC FORMS OF STENOSIS OF THE LARYNX.

The earliest record of catheterization of the larynx is found in the writings of Hippocrates, who suggested that in cases of inflammatory cynanche, cannulas should be carried into the throat along the jaws so that air might be drawn into the lungs.

This suggestion was adopted by many of the ancient physicians until the discovery of bronchotomy (tracheotomy) by Asclebiades about a century before the Christian era. Catheterization was then lost sight of until 1780, when it was revived by Chaussier, who proposed the use of a laryngeal tube in the asphyxia of the new-born and to overcome obstruction due to disease.

Several attempts were made about this time to retain a catheter in the larynx but were unsuccessful owing to the sensibility of the parts.

Dissault in 1801, and many others after his time, appear to have had some measure of success in the treatment of laryngeal stenosis by this method, particularly in adults. But the retention of one end of a tube in the trachea, while the other protrudes either from the mouth or nose, is obviously impracticable in children.

The first and only attempt before my own to use a short tube in the larynx, that would allow the epiglottis to close over it, was made by Bouchut in 1858. His failure after a limited trial was due principally to his extravagant claims for the new operation as a substitute for opening the trachea before he had any results to show, and to his bitter denunciation of Trousseau's pet operation, tracheotomy, which Bouchut claimed had considerably increased the death rate from croup instead of diminishing it. Personal enmities therefore played a more important part than the merits or demerits of the new procedure in determining the final decision of the Academy against it.

A very complete bibliography of this subject under the titles of catheterization of the larynx, tubage of the glottis, and intubation will be found in a paper by Dr. Dillon Brown in the Transactions of the 9th International Medical Congress, section on Diseases of Children.

DESCRIPTION OF INTUBATION INSTRUMENTS.

A set of instruments for children, under the age of puberty, consists of six tubes (1) of different sizes and varying in length from one and a half to two and a half inches; an introducer, (fig. 2), an extractor, (fig. 3), a mouth gag (fig. 4), and scale of years (fig. 5). Each tube is provided with a separate obturator for the purpose of attaching it to the introducer and, by projecting somewhat beyond the distal extremity, produces a probe-point which prevents injury to the tissues on the detachment of pseudo-membrane during the operation. The numbers on the scale (fig. 5) represent years, and indicate approximately the ages for which the corresponding tubes are suitable.

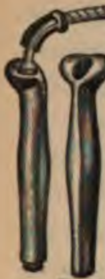

FIG. 1.

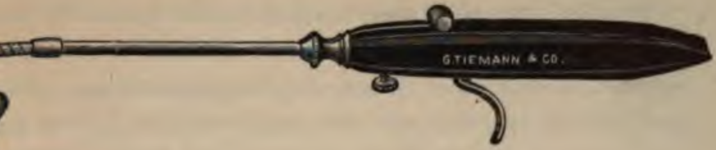

FIG. 2.

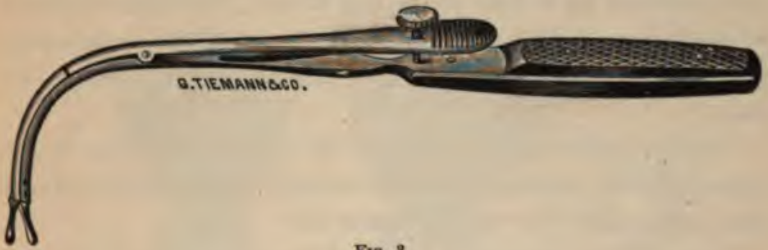

FIG. 3.

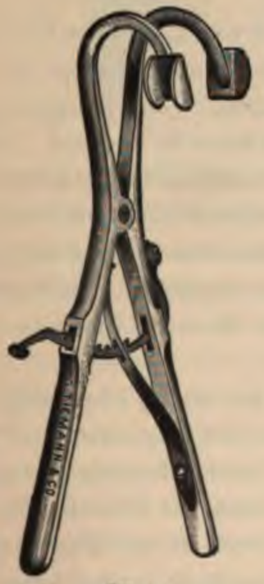

FIG. 4.

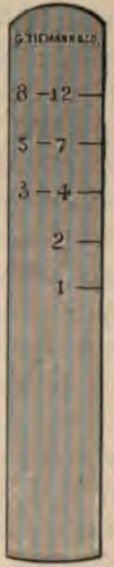

FIG. 5.

The smallest tube when applied to the scale will reach the line marked 1, and is suitable for children of one year and under. In children of fifteen months, small for age, this size is preferable to the two-year size, and it can be used at eighteen months, or even two years, without the slightest danger of passing through, but is apt to be coughed out. The next size, which reaches the line on the scale marked 2, is intended for children between one and two years, but can also be used at two and a half or three years with objection referred to above. The third size, marked 3–4 on the scale, should be used in cases over two and up to four years, and so on. The female larynx in children as well as in adults is smaller than the male, which should also be considered in selecting the proper tube to be used.

Owing to the rapid increase in the size of the larynx at the age of puberty, the string should be left attached to the largest tube when used after this period of life.

In measuring the tubes to select the proper size, the heads are of course included.

The tube indicated by the scale of years, is never too large to pass through any form of acute stenosis, except in rare cases of extreme subglottic infiltration of the mucous membrane, in which a smaller size may have to be used. Fig. 6 shows a specimen of this kind, with cross section through cricoid cartilage less than a quarter of an inch below the vocal cords. To pass the proper sized tube through a stricture of this nature, surrounded as it is by an unyielding cartilaginous ring, requires more or less force, and these are the only cases in which it is justifiable.

Fig. 7 represents the normal lumen of the subglottic division of the larynx from a child of the same age, and Fig. 8 a section from the trachea of the same showing the great difference in the caliber of the air passage at these points.

I have used the 5–7 tube at two years of age either to obtain the benefit of the increased length or larger head, and this can be adopted where there is pseudo-membrane producing obstruction at the lower extremity or swollen tissue overlapping the head of the smaller tube. Greater interference with deglutition and the danger of ulceration if the tube be long retained, are the only objections to this plan. All such indications could be met by a greater variety of tubes.

When the proper tube for the case to be operated on has been selected, a strong thread of silk or linen is passed through the small eyelet intended for this purpose, and the ends tied together. Braided silk is the best, as it will not unravel if one strand should cut and thus block the opening, which sometimes happens with the twisted variety. Leaving this string too short has been the cause of much annoyance to several operators and alarm to the friends of the patient by allowing the tube, when placed in the œsophagus, to slip into the stomach, which it quickly does if the malposition be not recognized. This accident can always be avoided by leaving the thread long enough to reach the stomach and still leave a portion protruding from the mouth. The obturator is then screwed firmly on the introducer to prevent the tube from rotating while being inserted, which would be liable to bring the posterior projecting portion of the flange under the epiglottis.

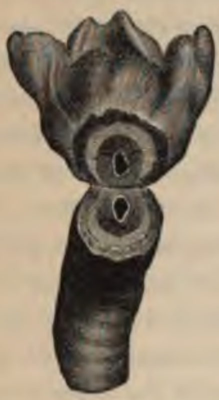
FIG. 6.

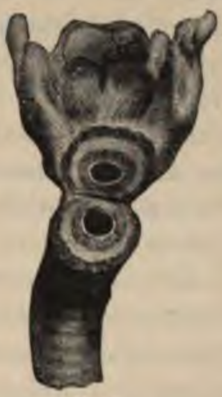
FIG. 7.

FIG. 8.

The upper end of the tube is curved backward and the shoulder removed anteriorly to allow greater freedom to the epiglottis during the act of swallowing.

The long diameter of the tube when applied and ready for use, should be in a line with the handle of the introducing instrument. If found to turn too far, as usually happens after considerable use, a washer of writing paper, of one or more thicknesses, is sufficient to hold the obturator in the proper position. If the lower extremity of the obturator does not project far enough beyond the tube to make a smooth blunt point, it will be found that the thread is too thick or is not in the groove corresponding to the hole in the tube. In most of the instruments made at present, the eyelet is in the left anterior part of the shoulder, which removes this difficulty.

Indications for Intubation.—The indications for intubation are the same as for tracheotomy. There is no reason why one should be performed earlier than the other. The beginning of the third or suffocative stage is the proper time to interfere. This is marked by more or less sinking in of the yielding portions of the chest, lower ribs and sternum, episternal notch, and supra-clavicular regions with inspiration. It means simply that air cannot gain admission to the lungs in sufficient quantity to fill the partial vacuum created by the expansion of the chest, and the walls recede under the weight of the atmosphere. It is more marked in very young or rachitic children owing to the greater elasticity of the ribs. But it should be remembered that this symptom is not peculiar to stenosis of the larynx and trachea, as it is produced to a lesser degree by obstruction in any part of the respiratory tract that interferes with the free inflation of the lungs. It is found in capillary bronchitis, extensive deposits of pseudo-membrane in the bronchi, atelectasis, and to some extent even in broncho-pneumonia. Recessions at the root of the neck are more significant than those below, as the violent contractions of the diaphragm aid in drawing in the free border of the ribs and sternum.

When recessions are marked there is little or no respiratory murmur over the posterior portion of the chest, but this symptom is not always available owing to the laryngeal stridor.

Atelectasis with excessive quantity of blood in the lungs, as would naturally be expected, is the result of death from obstruction in the larynx, but there are exceptions to this rule, and these organs are occasionally found distended with air and containing less than the normal amount of blood. This acute general emphysema, which produces bulging of the parts that usually recede, is caused by greater impediment to expiration than inspiration, and air accumulates in the lungs in the same manner as in spasmodic asthma. It is not common in croup, but is worth remembering. It is also occasionally found in capillary bronchitis.

The downward movement of the larynx with inspiration is pathognomonic of serious obstruction in this organ, and is also the result of atmospheric pressure, the air being prevented from entering with sufficient rapidity to fill the partial vacuum below. It is readily detected in adults, but not so in children, owing to the deeper situation of the larynx in the latter.

This symptom is not present in stenosis of the trachea, owing to the great elasticity of this tube, which permits of considerable motion on itself without displacing the larynx.

Abiding cyanosis is too late a symptom to wait for, and, besides, it is uncertain, as fatal obstruction may exist in the glottis with extreme pallor of the surface. This pallor of asphyxia is produced by the excessive quantity of blood drawn into and stored in the lungs by the cupping-glass action of inspiration when the air is almost excluded. The blood in the cutaneous capillaries is thus reduced to a minimum, and this, although highly charged with carbonic acid, only serves to increase the paleness, on the principle that the addition of a little blue makes a clearer white.

The temporary cyanosis which comes and goes with the paroxysmal dyspnœa of the second stage of croup is of no particular significance.

Children seldom remain long in one position when suffering severely from want of breath, and continued restlessness, if consciousness be unimpaired, is therefore an important indication that it is time to afford relief.

As far as the necessity for intubation is concerned, it matters little as to the nature of the obstruction provided it be in the larynx and not a foreign body. It may be croup, simple laryngitis, œdema of the glottis, paralysis, spasm, or even a neoplasm. In the latter it will tide over the immediate danger of asphyxia, and leave more breathing room to facilitate the radical operation.

Method of Operating.—The nurse or person who holds the child should be seated on a solid chair with low back, and the patient placed on the lap with head resting on left shoulder of nurse in order to leave the gag free. The hands can either be held, or, still better, secured by the sides by a towel or sheet passed around the body and left in that position until the tube is inserted and the string removed. Fastening the hands in front of the chest or thick garments in the same location renders it more difficult to depress the handle of the introducer sufficiently to carry the tube over the dorsum of the tongue.

The gag (fig. 4) is then inserted well back behind or between the teeth in the left angle of the mouth and opened widely, care being taken not to do it too suddenly or to use too much force. In children who have not at least one bicuspid on the left side, the gag should not be used, as it slips forward on the gums, and, besides being in the way, is liable to injure the incisor teeth. There is little difficulty in these cases in keeping the mouth sufficiently open with the finger, if carried far enough to the patient's right to be out of range of the front teeth. Allowing the child to compress the finger between the gums for a few seconds until the jaws relax, before carrying it into the fauces, avoids the necessity for using force.

The Denhardt gag, which is the one shown in the cut, holds better than the one originally devised by the author, the handle of which projects downward and is liable to be knocked out of place by coming in contact with the shoulder in the movements of the child's head.

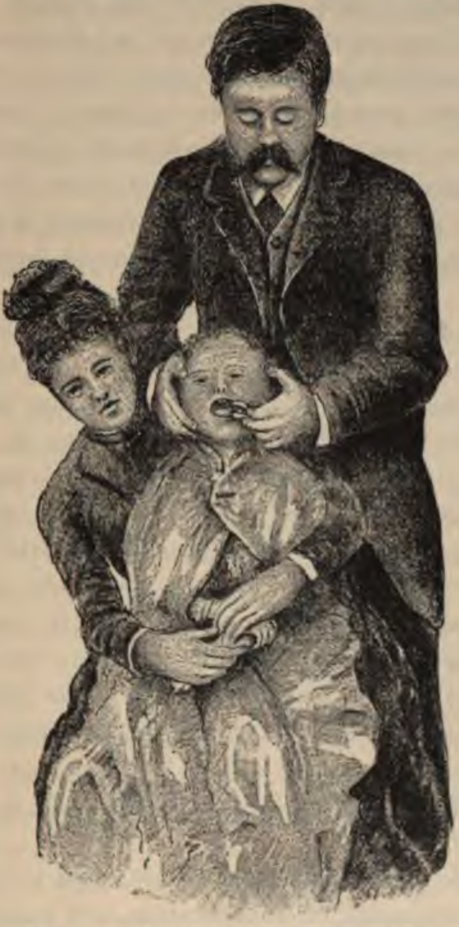

FIG. 9, shows the positions of assistant, nurse and patient with gag in position.

An assistant stands behind the patient and holds the head firmly by placing one hand on either side, and at the same time slightly elevates the chin. The person who holds the head, if without any experience, should be requested not to touch the gag, as this, if properly placed, retains its hold by the pressure of the teeth.

The operator stands in front of the patient holding the introducer lightly between the thumb and fingers of the right hand, the thumb resting on the upper surface of the handle just behind the knob that serves to detach the tube and the index finger in front of the trigger support underneath.

Held in this manner it is impossible to use force enough to make a false passage, while if firmly grasped in the hand the beginner may, unconsciously, exert sufficient force to lacerate the tissues.

The index finger of the left hand is carried well down in the pharynx or beginning of œsophagus and then brought forward in the median line, raising and fixing the epiglottis, while the tube is guided along beside it into the larynx. If any difficulty is experienced in locating the epiglottis, it is better to search for the cavity of the larynx, a *cul de sac* into which the tip of the finger readily enters and which cannot be mistaken for anything else. Once in this cavity the epiglottis must be in front of the finger and the latter is then raised and pressed towards the patient's right to leave room for the tube to pass beside it. The distal extremity of the tube should be kept in contact with the finger, and even directing it a little obliquely towards the right side of the larynx is necessary to get inside the left ary-epiglottic fold, especially in very young children.

The handle of the introducer is held close to the patient's chest in the beginning of the operation, and rapidly raised as soon as the lower end of the tube has passed behind the epiglottis, otherwise it will slip over the larynx into the œsophagus.

Some operators hold the introducing instrument in the horizontal position until the tube is well back in the fauces, and then swing it around to the middle line and complete the operation in the usual manner. The beginner is liable to forget the latter movement, which is the only objection to this plan.

As soon as the cannula is inserted it is detached by pressing forward the button on the upper surface of the handle with the thumb, while counter-pressure is made with the index finger on the trigger beneath. In removing the obturator—the joint in the shank of which is intended to facilitate this part of the operation—the movements required for insertion are reversed. To prevent the tube from being also withdrawn, the finger must be kept in contact with its shoulder either on the side or posteriorly.

The tube should be carried well down in the larynx before detaching it, otherwise the lower aperture will be left open and liable to strip off pseudo-membrane as it is subsequently pushed home with the finger.

The gag is removed as soon as the tube is in place, but the string is allowed to remain long enough to be certain that the dyspnœa is relieved and that no loose membrane exists in the lower portion of the trachea. In some cases the presence of the thread is desirable because it excites more cough, which is necessary to expel accumulated secretions and to inflate any collapse of the lungs that may have taken place. In removing the string the finger must be re-inserted to hold the tube down, but the gag is rarely necessary, as children old enough to understand readily open the mouth for this purpose.

In withdrawing the tube the child is held in the same position, and the extractor is guided along the side of the finger, which is brought in contact with the head of the cannula and then pressed toward the patient's right in order to uncover the aperture and allow the instrument to enter in a straight line. Dr. Waxham and others pass the extractor under the finger, that is, between it and the epiglottis, and intubate in the same manner. I have not tried this method and cannot therefore express an opinion as to its merits. No attempt at extraction should be made until the head of the tube is felt, which can always be done no matter how extensive the swelling of the epiglottis and ary-epiglottic folds may be. Many times the tissues have been lacerated by repeated attempts to remove a tube from the larynx which was somewhere else, most likely in the bed or ejected, unobserved, or passed during the act of vomiting, and thrown out.

The tubal cough is characteristic, and when once heard cannot be mistaken, but it sometimes assumes a hoarse or croupy quality from loose membrane below or overhanging tissues above, and in such cases the presence of the tube must be demonstrated by the sense of touch.

To place a tube in the larynx of a struggling, choking child, in the brief space of time that is compatible with safety, is a difficult thing to do, and should not be attempted, except in case of emergency, without previous practice on the cadaver. Those only who possess an extraordinary amount of dexterity combined with coolness will succeed without such practice. The operator has so many things to think of and so many movements to make with both hands, all in a few seconds, that unless he have had sufficient practice to make some of these movements to a certain extent automatic, he cannot operate with safety to his patient or with credit to himself. The epiglottis must be found, raised and held in this position, as the tube is glided down in contact with the finger, otherwise the operator does not know where it is; it must be slipped off at the right moment and held down while the obturator is withdrawn, all to be accomplished in ten seconds or less. It is this important element of time, therefore, that converts an otherwise simple operation into a very difficult one.

Practice on the cadaver is within the reach of comparatively few, but a larynx from any of the smaller animals can be procured by every one; and repeated practice on this, placed upright in the neck of a bottle or other convenient receptacle, is an excellent substitute. I have always advised those to whom I have given practical instruction on this subject to continue this kind of practice at frequent intervals, because a few lessons on the cadaver are not sufficient to insure proficiency and have only the advantage over this method of learning to operate in the same small space that exists in the living subject.

The larynx should be placed in the same position it occupied in the body, the operator going through the different steps of inserting and removing the tube solely by the sense of touch without watching his own movements, and when any obstacle is encountered holding the introducer or extractor in position until he investigate the cause of the difficulty. An hour's rehearsal of this kind just before going to remove a tube from a patient is of the greatest advantage, and gives an amount of confidence that contributes largely to a successful result.

I have found the greatest difficulty in overcoming the habit, always adopted by beginners, of placing the thumb on the lever of the extractor while guiding it into the tube. The most expert operator cannot do this without running the risk of unconsciously making slight pressure too soon, thus separating the nibs, which are very liable to seize some of the tissues as they close, besides otherwise interfering with the success of the operation. The thumb should be constantly occupied by placing it on the upper surface of the handle until the instrument is introduced, then transferred to the lever and continuous pressure kept up while the tube is being removed. Intermittent pressure will allow the tube to drop off into the pharynx and possibly to enter the stomach.

Intubation performed by an expert is an operation that may be witnessed by the most sympathetic mother without material shock to her nervous system, while in the hands of the novice there are few operations more repulsive even to the uninterested spectator. A small percentage of the amount of practice required to make a good marksman, billiard-player, ent, if expended in the manner above indicated, would impart sufficient dexterity to obtain the best results with intubation, and at the same time avoid a great deal of unnecessary suffering and some loss of life also.

The proper time for removing the tube from the larynx will depend on the age of the patient, the character of the disease, whether of slow or rapid development, and the progress of the case.

In one hundred and fifty-eight recoveries from croup, in which the exact time was recorded, the average retention of the tubes amounted to five days and two hours. In my own forty-nine recoveries, the longest time a tube was retained was fourteen days, and the shortest time in which pseudo-membrane was demonstrated to have been present was fourteen hours.

The younger the patient, as a rule, the longer the tube will be required. In children under two years of age it is better to leave it in seven days.

When the disease has developed slowly, and has therefore run a greater part of its course before calling for operative interference, the tube can be dispensed with earlier—sometimes as soon as the second or third day.

If the case be at such a distance as to render it impossible to reach it in a reasonable time, it is safer, if progressing favorably, to leave the tube in position for seven or eight days, and the exceptions are few in which it will be necessary to re-insert it after this time.

The tube should always be removed on the recurrence of severe dyspnœa, because it is sometimes impossible to ascertain with certainty whether it be partially obstructed or not. The best evidence to the contrary is a good respiratory murmur or numerous râles over the lower posterior portion of the lungs. Even under these circumstances I have occasionally found the lumen of the tube seriously encroached upon by firmly adherent secretions.

In one case of this kind, complicated with extensive broncho-pneumonia to which the dyspnœa was attributed, the tube when removed appeared to be completely occluded through its whole length, yet an opening must have existed in it somewhere. Had I found it in this condition on its removal after death I would certainly have attributed the fatal result to this cause.

Such cases—and I have seen several similar ones—prove that sufficient air to sustain life can be admitted through an extremely small opening. The adhesion of tenacious secretions to the inside of the tube is more liable to occur in very young children, owing to their comparatively feeble power of coughing, and for the same reason they are more prone to pulmonary complications. In older children who are strong and can be induced to cough vigorously such accumulations are rare. They are also favored by a high temperature, which is usually attended with scanty secretion, and particularly if at the same time both nostrils are occluded, necessitating mouth breathing.

I have never known any serious diminution of the lumen of the tube to occur suddenly from secretions. It is a process that usually requires at least many hours and sometimes days.

The development of a high temperature, especially if accompanied with any considerable amount of bronchitis, on the third or fourth day, is a sufficient reason for removing the cannula, as it can sometimes be permanently dispensed with as early as this, and even if left out for only a few hours without urgent dyspnœa, is of great benefit, as it affords an opportunity to unload the bronchi of secretions by permitting complete closure of the glottis and thus giving full effect to the act of coughing. In those cases that refuse nourishment after intubation or that cannot be induced to take a sufficient quantity, it is useless to remove the tube for the purpose of feeding, unless it have been in long enough to give some reasonable hope that its further use will not be necessary, as it is difficult to convince children for some time that they can swallow any better than before.

If no dyspnœa recur in half an hour after the extraction of the tube, it is safe to leave the patient, if not at too great a distance to be reached within two or three hours.

Accidents and Dangers of Intubation.—The most serious of the accidents incident to this operation is apnœa from prolonged attempts to introduce the tube. This can be avoided only by acquiring thorough familiarity with the use of the instruments in the manner already pointed out. The beginner, unless he possess an unusual amount of coolness, is liable to forget that while his finger is in the throat, the patient cannot breathe, and that a fatal asphyxia may be produced in a very few seconds. Ten seconds is the longest time that should be occupied in each attempt, if the child be suffering from urgent dyspnœa at the time. If the finger be then removed from the mouth, and the patient be given a chance to get its breath, many failures to properly place the tube can be made without danger.

The expert seldom requires more than five seconds to complete the operation, except in difficult cases, such as a very small mouth and throat, marked increase in the size of the tonsils, especially if chronic, extreme tumefaction of the epiglottis and ary-epiglottic fold which changes or obliterates the usual landmarks, and the struggles and resistance sometimes offered by older children when intractable. In the latter, although I have never had to resort to it, the administration of an anæsthetic would be less injurious than the exhaustion and cyanosis induced by a prolonged struggle without it.

If the tube has once passed on the outside of the larynx, and this is recognized before it is detached from the obturator, it is useless to try to rectify the position without first depressing the handle of the introducer as in the beginning of the operation, because owing to the length of the tube the palate arrests the upward movement before the distal extremity reaches the level of the glottic opening.

In croup the ventricles of the larynx are usually obliterated by swelling of the tissues and covered over by the pseudomembrane, and therefore seldom offer any obstacle to the passage of the tube on the first introduction; but when the stenosis persists longer than usual and reintroduction becomes necessary, it is well to remember that this may be a source of obstruction. The tube once having entered a ventricle, a moderate amount of force is all that is necessary to make a false passage. I have known this accident to occur when the operator was unconscious of having used any force whatever.

If the patient's head be thrown too far back, the tube may also be arrested by coming in contact with the anterior wall of the larynx or trachea.

Pushing down membrane before the tube is the most serious of the unavoidable accidents attending this operation.

It has happened in only three of my own two hundred and nine cases of croup, so far intubated, on the first introduction. In two of these apnœa was complete, and the tubes had to be removed immediately and were followed by complete casts of the trachea. In the third case expiration only was seriously obstructed, and the tube was allowed to remain about ten minutes in order to allow the lungs to become fully inflated, and to make more room in the glottis for the passage of the pseudo-membranous mass. As traction was made on the thread, the patient was directed to cough, and with the same result as in the others.

In none of these cases was the dyspnœa relieved in the least by the rejection of the membranes, and the immediate reintroduction of the tube was necessary in each. Had the obstruction existed in the trachea, the relief would have been prompt, but it was in the glottis, where the fibrinous exudation remains long adherent and where the principal cause of the stenosis is the infiltration of the mucous membrane and underlying tissues and not the film of adventitious material on the surface.

The trachea being so much larger than is required for the free passage of air to and from the lungs that no amount of fibrinous exudation, however thick, while still adherent, can produce serious impediment to respiration, this accident can only occur when a cast, or partial cast, lying loose in the trachea accumulates before the tube in its downward course, or the membrane being adherent above and detached below may close around the distal extremity of the tube, and partially or completely suspend expiration. I have had three deaths from the latter cause in two hundred and nine cases, occurring from one to three days after intubation. In two of these the presence of membrane below the tube was recognized immediately after the operation, but as it did not interfere with respiration at the time, the precaution of leaving the string attached was not taken, and both children were old enough to render this plan feasible. Pushing down pseudo-membrane is more liable to occur in cases of slow development, because it has had time to become detached, and for the same reason on reintroducing the tube after its removal for any cause. When not held below by processes extending into the bronchi, it is almost invariably expelled on again removing the tube. In some cases I have succeeded in breaking up such adhesions by inserting a longer tube or by inserting and removing the tube several times in succession.

I have devised and tried several instruments for the removal of pseudo-membrane from the trachea, which have not proved satisfactory. The one shown in the cut (fig. 10) I have not yet used. It is introduced closed and expands with a spring below and hugs the sides of the trachea while being withdrawn. It is of sufficient length to reach to the bifurcation and therefore much more difficult to insert than a tube. Even if completely successful in accomplishing the object intended, it would be useless, if not dangerous, in the hands of any but an expert. Other means of minimizing the danger of sudden occlusion of the tube by loose membrane in the lower portion of the trachea are available and within the reach of all. The most important of these for older children who are under control has already been referred to. It consists in leaving the string attached and fastening it behind the ear in cases in which the existence of pseudo-membrane below the tube is demonstrated, immediately after the operation, by a hoarse or croupy quality of the cough or a flapping sound with respiration or coughing.

In only one out of several cases in which I resorted to this plan during the past year was it necessary for the attendant to remove the tube. The patient was seven years old, and made no complaint of suffering or annoyance from the string. A cast of the trachea had been expelled several days before the operation. was necessary, and another had formed, its presence being manifested not only by the symptoms given above, but also by the occasional complete arrest of the escape of air during violent expiratory efforts, such as coughing. During quiet breathing, neither respiratory act was interfered with. The patient was warned against touching the thread or cutting it with the teeth. The father who acted as nurse was directed to watch her closely, and in case of sudden choking to pull out the tube. During a fit of coughing in the night. sudden dyspnœa developed, the father did as directed,

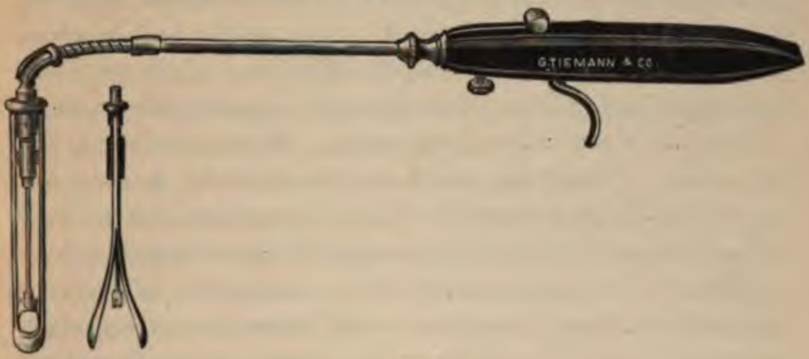

FIG. 10.

and a cast of the trachea was expelled. The next day the tube had to be reinserted for a short time, but the patient recovered, having retained the tube in the larynx in all only fourteen hours.

It is difficult to leave the string attached in young children, for if they do not succeed in seizing it with the hands they will soon chew it apart. The latter difficulty may be overcome when there is room to pass the thread between two of the double teeth. When this plan cannot be adopted, a smaller tube than the one suitable for the age should be used, which seldom fails to be rejected if obstructed. In a child between one and two years of age, for example, the No. 2 tube should be removed and the smallest one substituted; at six and a half or seven years the 5–7 size should be replaced by the 3–4. In the practice of this method, the worst that can happen is the rejection of the tube when it is not necessary. Should this occur too frequently, a larger size would have to be used. In some few cases even the proper size for the age as indicated by the scale is coughed out so often that a larger one must be inserted.

Either of these plans should be resorted to in case the symptoms of loose membrane in the lower part of the windpipe, absent at the time of operation, subsequently show themselves.

In the event of sudden asphyxia, the nurse should be instructed to quickly grasp the child and hold it head downwards, at the same time shaking it vigorously, the weight of the tube being sometimes sufficient to displace it.

The obstruction in the great majority of these cases is to expiration only, inspiration being free. Air in excessive quantity therefore rapidly accumulates in the lungs, and this may be used as the expelling power by causing some of it to escape suddenly, in imitation of the act of coughing, by a forcible blow or slap with the open hand on the front of the chest, at the same time preventing the descent of the diaphragm by pressure of the other hand on the abdomen. It will be more likely to succeed if the patient be placed across the knees or other hard surface than if practiced on the bed.

If complete occlusion exists death probably results in less than one minute, and whatever is done must be done quickly, and by the nurse, as there is no time to summon the physician.

During the fit of coughing that immediately succeeds intubation, pieces of pseudo-membrane are frequently expelled. These are usually only fragments detached from the chink of the glottis or anterior wall of the trachea and carried down with the tube, but they sometimes amount to considerable masses; even a cylindrical cast almost an inch long I have known to be forced through the small opening in one of the medium-sized tubes.

I have never known any serious obstruction to result from loose membrane above the tube, but extreme tumefaction of the epiglottis and ary-epiglottic folds does in rare cases give rise to dangerous constriction at this point.

In one case I recognized this condition from the noisy obstructed inspiration, and easily detected the overlapping tissues by inserting the finger. This difficulty can be overcome by coating the head of the tube with several layers of collodion, which, if allowed sufficient time to dry, will adhere for a considerable length of time, or a larger tube can be used.

Gradual accumulation of tenacious mucus sometimes mixed with milk-curd occasionally takes place in the tube and renders its removal for the purpose of cleaning necessary. It is more liable to occur in those cases that cough but little, also in very young children or where there is marked prostration, because the expulsive power of the cough under these circumstances is slight. For the same reason, when the lumen of the tube has been seriously encroached upon in this manner it is seldom expelled, as the volume of air admitted at any one time is comparatively small.

Coughing out the tube when it is free from obstruction and before the stenosis has been permanently relieved does not often occur when the proper size has been used, and is seldom attended with any danger, as the dyspnœa does not return immediately, except in those rare cases in which there is extensive œdema of the glottis or complete paralysis of the abductor muscles of the cords. In either of these conditions, when recognized, a larger tube than that suitable for the age should be used; or, what is still better, a tube specially constructed for the case, with extra large retaining-swell. This is particularly important in paralysis, which is likely to persist for a considerable length of time, because the retaining power which resides principally in the vocal cords must be transferred to the subglottic division of the larynx.

The tube is more liable to be expelled in the act of vomiting than by coughing, as the vocal cords in the latter are contracted, while in the former the weight of the tube sometimes favors its rejection from the position the patient, if permitted, is apt to assume, with the head on a level with or lower than the body.

Owing to the difference in the size of the larynx in different children of the same age, it is impossible to adjust the tubes so that they will be retained under all circumstances while clear, and at the same time permit of their rejection when suddenly occluded.

The most serious injury may be done to the larynx in attempting to remove the tube if the extractor be passed down beside instead of into the opening, and it is often impossible even for the expert to locate the point of the instrument with certainty before separating the blades. It is important therefore to remember that no force whatever is required to remove the tube, and that any resistance to the withdrawal of the extractor proves that it is caught in the tissues on the outside. By forcibly removing the instrument under these circumstances I have known sufficient laceration to be produced to allow the tube to drop in the trachea, and this is the only way in which this accident can occur with the large-headed tubes now in use.

To minimize this danger as far as possible a regulating screw has been added to the extractor, which prevents the blades from opening any wider than is required to hold the tube with sufficient firmness to prevent slipping, and can be adjusted to suit the different sizes. Most of the old instruments are too slight, and therefore too elastic, to render the addition of this screw of any service.

Attention to the following points will enable every one to detect the most serious defects found in many of the tubes still in the market.

The head or shoulder which rests in the vestibule of the larynx, and which is firmly grasped by the surrounding tissues during every act of swallowing, should be absolutely free from any roughness or sharp edges that would cut into or irritate the intensely inflamed mucous membrane. This portion of the tube—about one-fourth of an inch—has a slight backward curve which, if not apparent, can readily be detected by placing the anterior edge in contact with any level surface. Its object is to give greater freedom to the epiglottis in preventing the entrance of food during the act of swallowing, and to avoid ulceration, which was not an uncommon occurrence with the straight tubes first used. For the same reason there is no flange anteriorly, and the metal here is left thick enough to prevent the formation of a cutting edge, as the epiglottis is pressed with considerable force on this part with each deglutition. Those not familiar with the object of this consider it a serious defect because occupying room that should be devoted to the calibre. The metal on the anterior surface of the lower extremity should be even thicker than above, and smoothly rounded off so that it will glide up and down over the mucous membrane without cutting it.

The upper extremity of the tube being fixed, is raised with the larynx and at the same time pressed backwards by the base of the tongue, which pushes the epiglottis before it. This lever action brings the distal extremity in contact with the anterior wall of the trachea, and instead of occupying a fixed position, as it does above, moves about half an inch in a vertical direction. The upward movement, coincident with closure of the epiglottis while swallowing, is harmless, but the injury is inflicted as the tube, still in contact with the mucous membrane, returns to what may be called its respiratory position.

If long worn, even the most perfect tube will produce some abrasion of the inflamed and infiltrated tissues at the point indicated, from the frequent rubbing, which occurs with every act of swallowing, either of saliva or of food, and probably amounting to over a hundred times daily. If the tube be rough or have a sharp edge at this point, it will inflict serious injury on the mucous membrane even to laying bare the cartilaginous rings.

The ulceration thus produced is sometimes the cause of dysphagia, and is in all probability the source of the blood that occasionally tinges the expectoration several days after intubation.

The retaining-swell protects the sides of the trachea, and therefore the metal on the lateral aspects of the distal end should be thin in order to leave the entering portion of the tube small to facilitate its introduction.

As the tube seldom impinges on the posterior wall the metal at this point need not be so thick as in front, but sufficiently so to make it blunt and smooth.

Another very serious defect, and a very common one, is the imperfect fitting of the obturator in the tube both above and below. If this exist below, it fails to make a perfect probe-point and is liable to injure the tissues of the larynx or scrape off pseudo-membrane in its downward course. If above, it allows the tube to wobble when attached to the introducer, and if the operator fail to place it in the larynx on the first attempt the tube is certain to slip off, and besides the annoyance, he is obliged to lose valuable time in readjusting it. This is even liable to happen in striking the base of the tongue or other part before the larynx is reached. If properly made the tube and introducing instrument, when united and ready for use, should be as free from motion as if constructed of one piece, and this, owing to the joint in the shank of the obturator and the curve in the upper part of the bore of the tube, is difficult to obtain.

I have also noticed that the lines indicating the years on the scale do not always correspond to the length of the tubes, rendering it difficult for the beginner to select the proper size. By observing the following rule the scale can be dispensed with. The smallest tube is suitable for the first year of life, the second for the second year, the third from two to four years, and the others for two years each.

No instrument-maker has yet succeeded in constructing these tubes properly without repeated instructions and many failures. It is therefore not surprising that those who never received any instruction whatever should turn out such grossly imperfect instruments as are constantly to be found in the market.

Diagnosis of Croup.—Croup, from its characteristic symptoms, should be one of the easiest of all diseases to diagnosticate, and as a rule it is, but in cases seen for the first time, when moribund or nearly so, the cough having ceased and nothing remaining but the labored breathing, it is sometimes impossible with the imperfect history obtainable from the excited parents or friends to differentiate dyspnœa due to this disease from that produced by other causes. While doubt under such circumstances is justifiable, I know from personal experience that mistakes for which there is no excuse are occasionally made and that would never occur, were a little attention paid to the prominent symptoms of croup.

These symptoms in the order of their importance are the following: The peculiar character of the cough, of the breathing, the hoarseness or aphonia and dyspnœa. The croupy cough may be called a constant and characteristic symptom, for the cases in which it is absent with pseudo-membrane in the larynx can safely be excluded on their rarity.

The croupy or noisy breathing is almost always present, but not marked in the early stage of the disease.

Hoarseness is a very early symptom, and occasionally precedes the croupy cough by a considerable length of time. It is almost always followed by aphonia or complete loss of voice, except with violent effort, when it is usually possible to produce a distinct sound. Aphonia in children should always be regarded with grave suspicion, as in rare cases it is the only evidence of laryngeal diphtheria; while, on the other hand, a fatal stenosis may exist in the narrow portion of the larynx just below the vocal cords without material alteration of the voice. It is particularly liable to occur in the ascending cases, in which the disease begins in the trachea and sometimes produces sufficient infiltration and thickening of the mucous membrane of the subglottic region to cause apnœa before any fibrinous exudation whatever has been thrown out. The cut (fig. 6) represents a specimen from a case of this kind. The voice, with the exception of weakness toward the end, was not altered and no pseudo-membrane existed at the seat of greatest constriction.

Dyspnœa, except that due to spasm which may occur at any stage of the diesase, is a late symptom, and is at first mainly inspiratory, but later, when the respiration assumes a sawing character, both respiratory acts are about equally obstructed, and occasionally the exit of air is more impeded than its entrance. In the latter case acute general emphysema is the result, with modification of some of the ordinary physical signs previously described.

It may be put down as a general rule that any impediment to respiration situated in the larynx or trachea, or produced by pressure on these parts from the outside, gives rise to greater obstruction to inspiration than to expiration. The reverse is also true in several of the respiratory diseases located below these points, such as spasmodic asthma, emphysema, capillary bronchitis, and the pressure of enlarged bronchial glands on or in the immediate vicinity of the bifurcation. In two cases of the latter which I have observed and verified, the dyspnœa was markedly expiratory or asthmatic, and while it is not probable that this always obtains, it is worth remembering as an aid to diagnosis in obscure cases.

The following diseases are those most commonly mistaken for croup, according to my own experience: Naso-pharyngeal obstruction from intense tumefaction of the tonsils and other tissues at the entrance of the fauces, with co-existing occlusion of the nares. In two out of several such cases seen during the past year, all malignant forms of diphtheria, there was marked cyanosis, which disappeared as the swelling subsided under the influence of warm, mildly astringent irrigations; but all eventually proved fatal from the severity of the disease. The noisy breathing simulates that of croup, but the cough and voice are unaffected.

I have seen some cases in which croup complicated this condition where it was difficult to determine as to how much of the dyspnœa was laryngeal and how much pharyngeal. Temporarily conveying the air beyond the pillars of the fauces by the insertion of a large catheter or other means would under these circumstances be decisive.

It should be remembered also that with such a degree of malignancy, the intense inflammatory œdema of the surrounding tissues may dip into the vestibule of the larynx and produce fatal stenosis without implicating the cords and before pseudo-membrane has had time to form. The introduction of an educated finger is the best aid to diagnosis in this case.

To be able to locate the seat of the impediment to respiration when called upon to intubate, and to decide whether the operation, which cannot remove obstruction in the pharynx, be indicated or not, is the only advantage to be derived from exact diagnosis in this class of cases, as they always prove fatal as far as I have seen.

Retro-pharyngeal abscess is more liable to be confounded with œdema of the glottis than with croup, for the reason that in both inspiration only is obstructed, but deglutition is also interfered with in the former.

Abscess in this location is likely to be overlooked simply because being comparatively rare it is not thought of. The attention once having been called to it, the diagnosis is easily made either by sight or by the sense of touch. The finger comes in contact with a soft doughy swelling instead of the hard posterior wall of the pharynx. All the cases of retro-pharyngeal abscess seen by the author were in children under two years of age, and some of them were infants only a few months old.

Primary idiopathic œdema of the glottis is one of the rarest of diseases in children, and if mistaken for croup is of no importance as far as intubation is concerned.

Paralysis of the abductor muscles of the glottis only obstructs inspiration, and the more forcible this act the more closely the cords are approximated. It is almost exclusively a sequel of diphtheria, and in young children produces asphyxia in a very short time.

Laryngismus stridulus, or spasm of the glottis, is characterized by its sudden onset, crowing inspiration, and croupy cough. It is only the local manifestation of a general derangement of the nervous system, and often ends in convulsions. Intubation is sometimes indicated, but the paroxysm usually subsides or proves fatal before there is time to summon medical aid. Laryngeal polypi are of slow development, and affect the voice for a considerable length of time before the breathing.

In cases with obscure history and unusual symptoms it is well to remember that various kinds of foreign bodies may gain admission to the larynx and be retained for some time without producing complete asphyxia.

There is no possible excuse for any error in diagnosis between pulmonary or bronchial affections and croup which I have known to be made.

To differentiate simple catarrhal croup and fibrinous laryngitis is a matter of little importance as regards intubation, because the former rarely endangers life or calls for surgical interference, while only a small percentage of the latter recover without it. False croup usually makes its appearance suddenly in the night, followed by marked improvement or complete intermission during the day. Fibrinous croup, on the contrary, except in fulminant cases, is rather slow and insidious in its development, but steadily progressive, presenting at first only slight hoarseness with croupy cough, and attended with little constitutional disturbances, when neither nose nor pharynx is involved. A sharp rise of temperature, such as 104°, points rather to false than true croup. Albuminuria is diagnostic of the latter.

Medical advice is usually sought more promptly in the false variety, because it presents more alarming symptoms at the outset, than in the fibrinous form, which is often regarded with indifference until the breathing has become affected.

The much-vexed question of the identity or non-identity of croup and diphtheria would not be a subject of much practical importance, were it not for the fact that many lives are sacrificed every year on account of the duality theory. When a case is once diagnosticated as membranous croup, no precautions are taken to protect other members of the family, because it is not a contagious disease.

I can safely say that at least one-fourth of all the cases that I have been called upon to intubate were regarded as simple fibrinous laryngitis by the attending physicians. In many instances other children in these families subsequently developed diphtheria with fatal results in not a few.

When we consider the frequency with which diphtheria begins in the air-passages, and the number of physicians—which I know from personal experience to be in the majority—who still believe in the distinction between membranous and diphtheritic croup, the extent of the danger of unrestricted intercourse between the sick and the well can be readily appreciated.

While there may be, and probably is, such a disease as acute non-specific membranous croup in children, there is not a single sign or symptom by which it can be distinguished from diphtheria beginning in the glottis. The only plan, therefore, compatible with safety, is to isolate every case in which there is even a suspicion that pseudo-membrane may be developing in the larynx, and then contradictory opinions may be entertained without injury to any one.

The principal arguments advanced in favor of the duality of croup and diphtheria are that in the former the disease is confined to the air passages, and is not attended with the usual symptoms of the latter, viz.: asthenia, systemic infection, glandular enlargements, albuminuria and paralyses.

Those, on the contrary, who maintain the identity of these diseases regard the location or starting-point of the exudation as of no importance, and attribute the greater exemption from general infection and the absence of glandular enlargements to the smaller surface involved and the limited communication of the absorbent vessels of the mucous membrane of the larynx and trachea with the glands of the neck.

My own experience has led me to the conclusion that if we have a simple fibrinous croup in New York City or vicinity, it must be extremely rare. A very small percentage of the cases I have seen might have been of this nature, for any evidence to the contrary. Most of those so diagnosticated by the attending physicians were subsequently demonstrated to have been diphtheritic in the manner previously pointed out or by the presence of a large amount of albumin in the urine, as there is no reason for the latter complication in simple membranous laryngitis.

During fifteen years' service at the New York Foundling Asylum, I have observed that when that institution was free from diphtheria it was also free from croup, and that the prevalence of the latter always bore a direct proportion to that of the former. The same rule has also applied to private practice.

While we have no positive evidence, either clinical or pathological, that there are two forms of acute membranous laryngitis in children, yet there are some facts which demonstrate that diphtheria has not the exclusive right to produce this kind of exudation. Such, for example, is the false membrane that sometimes forms on blistered, burned or other wounded surfaces, and which has the same gross and microscopical appearances as that of diphtheria. Also that which occurs in the bronchi in chronic fibrinous bronchitis, which may last for months and even years, the duration alone being sufficient to exclude any possible connection with diphtheria, unless we admit the existence of a chronic form of this disease.

The following case is of particular interest in this connection. A few months ago, I was requested by a physician of this city to visit a relative of his who resided in one of the neighboring States, with a view to practicing intubation for the purpose of getting rid of a tracheal cannula that had been retained for some time. The patient was a man about thirty years of age, in excellent health, with the exception of the laryngeal stenosis. Five months before I saw him he had a severe attack of acute laryngitis, following exposure to cold, which in the course of two or three days necessitated the performance of tracheotomy to avert threatened asphyxia. The attending physician, in relating the history of the case, frequently referred to what he called sloughs, that had been ejected daily from the beginning of the attack, and were supposed to have come from the larynx. I requested the patient, if possible, to produce one of the so-called sloughs in my presence, which he did after a good deal of effort. I found it to be a piece of pseudo-membrane, almost square, and about half an inch in diameter, somewhat thinner than that ordinarily found in croup.

I submitted one of these specimens to Dr. W. P. Northrup, pathologist to the New York Foundling Asylum, for microscopical examination, who pronounced it identical in every particular with the fibrinous exudation of diphtheria.

In the mirror the deposit could be seen about equally distributed over both vocal cords and nowhere else.

When questioned on the subject, the patient denied syphilis, because fully convinced that he never had it; but he had a node on the shin at the time, which had been painful at night, and this, together with the laryngitis, was the only manifestation of the disease that had ever existed.

Under the influence of mercury and the iodide, the pseudomembrane disappeared in four days, and never returned.

Making all due allowance for the fact that the inflammatory trouble in the larynx was syphilitic, the rapid cure of the fibrinous element, which had persisted for five months uninfluenced by a variety of local applications, argues forcibly in favor of the mercurial treatment of croup.

This patient was in daily contact with children during the whole course of his disease, none of whom suffered from any affection of the throat.

Prognosis.—Diphtheritic or fibrinous croup without the aid of intubation or tracheotomy proves fatal in from 90 to 95 per cent. of the cases.

About 10 per cent. of those that I have been called to intubate finally struggled through without it, and in private practice, 27 per cent. with intubation. This makes a total of 37 per cent., which may be taken as the best results that can be obtained in a large number of cases extending over a sufficient period of time to include all types of the disease, mild and severe.

Those who practice either operation early, of course, include the cases that would otherwise recover if not interfered with, but this does not materially alter the average just given.

The latest intubation statistics are those compiled by Dr. Dillon Brown, who in the month of November, 1888, collected 2372 cases from 159 operators, with 646 recoveries, or 27.2 per cent.

The age of the patient, the character of the epidemic, the origin, nature, and extent of the exudation and the complications, are the important factors to be considered in estimating the probable termination in any given case. Of these, age is by all odds the most important.

Although several recoveries following intubation for croup in children under one year of age have already been reported, the percentage is very small. During the second year of life, there is a marked improvement in the results, and so on with increasing age, until the period of puberty is approached, when the statistics so far indicate a falling off in the percentage of recoveries. This may be explained by the fact that the liability to croup decreases with age, and that the number of older children so far intubated is too limited to warrant any conclusion on this subject. Furthermore, owing to the larger size of the larynx in these cases, recovery more frequently results without operation than in young children, and intubation is therefore only called for in the worst forms of the disease. For the same reason, when laryngeal diphtheria in the adult produces sufficient stenosis to require surgical aid, it indicates a malignancy of the disease that is seldom recovered from.

Croup that prevails during fatal epidemics of pharyngeal diphtheria is proportionately fatal and principally from the same causes, viz., greater frequency of systemic infection, of nephritis, pneumonia, and also greater tendency to invade the bronchial tubes. The latter is much more liable to occur when the disease begins in the larynx, than in those cases in which the exudation has existed for several days in the fauces, thus having run part of its course before invading the air-passages. For this reason the prognosis is less favorable in the so-called membranous croup than in the form that is recognized by all as diphtheritic.

Distribution of the pseudo-membrane over a large surface, as when with the larynx the nose as well as the fauces is involved, thick deposit, dark color of the exudation, foul odor, great tumefaction of the tissues in the throat and of the glands on the outside are unfavorable to recovery.

Cases with scanty secretion of urine with a perceptible amount of blood or large quantity of albumin, such as fifty per cent. or over, almost invariably terminate fatally. A more copious secretion with the same amount of albumin is of less serious import. I have never known albumin to be absent in severe cases, but it must be looked for daily, as the urine may be free from it one day, and loaded the next. A high temperature on the second or third day after intubation is an evil omen, because it usually indicates extension of the disease to the bronchi, sepsis, or pneumonia or all combined. When the laryngeal stenosis has persisted for some time, and is sufficiently pronounced to call for surgical interference, the temperature in the great majority of cases is little above the normal. This, to some extent, at least, is due to diminished oxidation in the tissues from the limited supply of air admitted to the lungs, and explains the rapid rise of temperature that not unfrequently occurs soon after intubation, and before sufficient time has elapsed for the development of any complication. Fever coming on in this manner is not so liable to persist, and does not possess the same prognostic significance as when it shows itself one or more days after the operation.

Children in the neighborhood of four or five years of age breathe, in health, about twenty-five times per minute. An increase in the number of respirations to forty or more usually indicates either a narrowing of the calibre of the bronchi by pseudo-membrane or pneumonia, the latter being a later development.

Any considerable invasion of the lower air-passages by the disease, almost invariably occludes some of the bronchial tubes, which is followed by collapse of the corresponding portions of the lungs, and this, together with the decrease in the lumen of the others, sufficiently explains the acceleration of the breathing when no pneumonia exists.

In young children it is not uncommon for the respirations under these circumstances to run as high as from eighty to one hundred or more per minute.

Treatment of Croup.—In estimating the value of any remedy in the treatment of croup, a disease so fatal under all circumstances and attended by so many grave complications, it is important to resist the temptation of being influenced by the result obtained in a few cases, whether it be favorable or otherwise.

The mortality from diphtheria, and consequently that from croup, varies so much in different epidemics, that it is necessary before arriving at any conclusion not only to observe a large number of cases, but also that these should extend over a sufficient period of time to include all types of the disease.

As my own views on the medicinal treatment of diphtheria and croup coincide so perfectly with those of the author of this work it is only necessary for me to indorse the method advocated by Dr. Billington, to which the reader is referred, and give some directions for the management of laryngeal diphtheria following intubation.

Of the many therapeutic agents that have been, and are still employed in the treatment of croup, I believe the bichloride of mercury deserves the first place. Very few, if any, of those who have used it, after having had sufficient experience with other remedies to render their opinion of much value, have abandoned its use after a fair trial.

After intubation the same treatment is continued, with the exception of an interval of two or three hours following the operation, during which nothing is given by the mouth, in order to allow time for the larynx to become accustomed to the presence of the foreign body. In some cases I have found it necessary to administer small doses of whisky or brandy undiluted soon after placing a tube in the larynx, for the purpose of exciting sufficient cough to expel accumulated secretions and loose membrane, the tube with string attached failing to accomplish this.

With a properly fitting tube in the larynx, the difficulty of swallowing is due principally to swollen condition of the epiglottis, which is common in croup. This is demonstrated by the fact that in other forms of stenosis in which the epiglottis is not involved, the difficulty of deglutition is soon overcome.

Some of the liquids swallowed undoubtedly gain admission to the trachea through the tube, but are promptly expelled by the coughing thus excited, and are therefore harmless. But should the sensibility be so much blunted that no reflex action follows the contact of extraneous matter with the lining membrane of the air-passages, there is nothing to prevent the gravitation of whatever passes through the tube to the smaller bronchi and alveoli. The impaired sensibility in such cases is due to some form of toxæmia which precludes any reasonable chance of recovery, and it is therefore scarcely worth subjecting the patient to the annoyance of feeding by stomach tube. But there are some cases that suppress the cough because it is painful, and in these the plan of feeding suggested by Dr. Castleberry, of Chicago, may be tried. It consists in overcoming gravitation by placing the head considerably lower than the body, and drinking through a glass tube, nursing bottle, etc., which allows any fluid that enters the tube to escape without coughing.

Some patients swallow better by taking a small quantity in the mouth at a time, others by filling the mouth. Infants at the breast swallow better than older children, and most cases can drink better from a nursing bottle than from a cup or glass, and on the same principle by sucking through a tube. Patients with high temperature, suffering from great thirst, will take a long drink without stopping to cough, although the desire to do so be very great. This should not be permitted, as it gives time for some of the liquid to enter the bronchi. The glass should be removed after every two or three acts of swallowing, and the child encouraged to cough. These precautions do not apply to cases that swallow well, which is not uncommon after the tube has remained in the larynx for a few days, if the functions of the epiglottis be not much impaired.

Nourishment in the solid and semi-solid forms, which are swallowed better than liquids, should be given the preference when children can be induced to take them.

Rectal feeding should be resorted to in case a sufficient amount of nutriment cannot be given by the mouth. Warm milk with whisky, to which the albumen of one or two eggs can be added, is the most convenient for this purpose. Peptonized milk or the expressed juice of meat is still better.

The Leube Rosenthal solution of meat, dissolved in warm water, is readily absorbed by the rectum if retained long enough, as I have demonstrated many times.

These injections should not be given oftener than once in three or four hours, or in larger quantities than one or two ounces to a child four or five years old, otherwise they are soon rejected. When the bowel becomes irritable, tolerance for small quantities is sometimes re-established by a large injection of warm water; and should this fail, a few drops of laudanum in warm sweet-oil or starch can be injected with a small syringe and allowed to remain about three quarters of an hour before using the nutrient enema. In this manner the bowel can be used many days in succession, and aids wonderfully in sustaining the vital powers until the patient can be induced to take a sufficient quantity of nourishment by the mouth.

Intubation cases are not the only ones that call for rectal alimentation.

It is not uncommon for children suffering from diphtheria or scarlet fever to refuse all kinds of nourishment for several days in succession, and if compelled to take it or it is given by the stomach tube, it is almost immediately rejected. Rectal feeding is just as urgently demanded under these circumstances as if the inability to take food were due to a tube in the larynx.

The most fatal of all the complications of croup is undoubtedly the extension of the disease to the lower air-passages, or fibrinous bronchitis; for the prevention of which there is no remedy known at present. Mercury, especially the bichloride, probably exerts some limiting or controlling power over the fibrinous exudation, which would sufficiently explain the more favorable results obtained with this than with any other remedy.

Nephritis is often a serious complication, but is usually in proportion to the severity of the diphtheria and the amount of systemic infection. Thorough disinfection of the absorbing surfaces in the throat and nose is therefore an important part of the treatment. The improvement in the albuminuria goes hand in hand with that of the original disease, and rapid recovery follows as soon as the poison is completely eliminated from the circulation.

From the physiological fact that urea is a constant constituent of normal sweat, and that its quantity is largely increased when there is a deficient elimination by the kidneys, free action of the skin is a rational and valuable means of carrying off excrementitious products that would otherwise accumulate in the blood and tissues when the function of the kidneys is seriously impaired. There is no better method of accomplishing free diaphoresis than that necessarily produced by the steam treatment under a tent. Under these circumstances the temperature of the air immediately surrounding the patient can be kept as high as 80° with advantage. Without the kidney complication, 75° is sufficient.

The high temperature that usually accompanies the pneumonia, fibrinous bronchitis, and sepsis can, in most cases, be kept within bounds by the use of antipyrin or antifebrin combined with digitalis, which, even if they accomplish nothing in the way of saving life, contribute a good deal to the comfort of the patient, by allaying the thirst and restlessness produced by the fever.

A sufficient amount of sleep should always be procured, and it is much better to give an anodyne for this purpose than to allow a child to pass a restless, wakeful night. If due to pain or irritation from the tube in the larynx or excessive cough, an opiate is the only remedy that will afford relief, otherwise sulphonal, in doses of from three to five grains, or a mixture of bromide and chloral, will answer the same purpose.

Many times in answer to the question whether the little patient had obtained any sleep during the night, I have been told by the mother that it would have slept, had she not been obliged to administer the medicine every half-hour or hour.

Nervous, irritable children who remain wakeful for some time after having been roused to take their dose, should be allowed at least three hours of uninterrupted sleep every night. From the unsatisfactory results obtained with any of the remedies at present within reach, I believe it is much safer to temporarily suspend medication than to seriously interfere with sleep.

Intubation in the Adult.—The operator who has acquired proficiency in performing intubation in children, will experience great difficulty when called upon for the first time to operate on the adult. The difference is due to the larger size of the larynx in the latter, but particularly to its greater distance from the mouth. It is only necessary to reach far enough behind the epiglottis to hold it erect, and this can usually be done by crowding the finger well back in the right angle of the mouth. In one case I failed absolutely, after repeated attempts, to do more than touch the tip of the epiglottis without inserting two fingers, which filled the pharynx and left no room for the passage of the tube. Intubation was finally accomplished in this patient by the aid of the mirror, which will probably prove the better plan for those familiar with laryngoscopic manipulations. In the latter case it is necessary to drop the mirror and quickly insert the finger to push the tube home and hold it down while the obturator is being removed, for if the thickest portion of the retaining-swell be not carried well below the cords, which is often impossible while still attached to the introducer, the tube is immediately rejected. The removal of the tube from the adult larynx can be accomplished with greater ease, and with less discomfort to the patient, by guiding the extractor into it by the aid of the mirror, than by the finger, as is necessary in children. Very little practice with the laryngoscope is required for this purpose.

For any form of acute stenosis of the larynx in the adult, two tubes of different sizes, the smaller for the female, the larger for the male, I believe will prove sufficient. But for the dilatation of chronic stricture, especially the cicatricial form, a set of about ten tubes will be required, and the larger of these can be used in acute cases in the adult male, the medium sizes in the adult female, and the smallest during the years of adolescence.

A special introducer and extractor, longer and much stronger than those used for children, are necessary.[1]

Intubation has already been successfully practiced in almost all the different varieties of stenosis that occur in the adult larynx, viz.:—Acute œdema of the glottis, erysipelatous inflammation, laryngeal diphtheria, perichondritis, syphilitic and tubercular laryngitis, paralysis of the abductor muscles of the cords, and temporarily, in neoplasm.

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[1] Tiemann & Co., of this city, is the only firm at present manufacturing tubes and accessory instruments suitable for adults.

In cases requiring the retention of a tube for several months, it is important to change the points of pressure in the vestibule of the larynx about once in two weeks, in order to prevent erosion of the mucous membrane, with consequent sprouting of fungous granulations, which is liable to occur from the compression exerted by the constrictor muscles during every act of swallowing. The larger head that goes with the increase in the size of the tubes required for the dilatation of the stricture, accomplishes this purpose until the maximum size has been reached, when the pressure can be transferred to other points by changing the shape of the shoulder of the tube. It can, for example, be lifted higher in the larynx by increasing the thickness in the vertical direction, having the diameter the same.

A hard-rubber tube may be allowed to remain in the larynx for a much longer time than one constructed of metal, because, owing to its lightness, it does not occupy a fixed position, but moves upward by coughing, and is again pressed downward by the act of swallowing.

Another objection to the long retention of a metallic tube is the fact that the gold-plating soon disappears in places, followed by erosion of the metal and the deposit of calcareous matter, which produces a good deal of irritation.

I have occasionally found some calcareous granules on tubes that were not long retained, and on which the plating appeared to have been intact.

The difficulty of deglutition that follows intubation in croup, and that often persists as long as the tube remains in the larynx, is not a prominent feature in chronic stenosis. The epiglottis being usually in a normal condition, soon learns to assume the whole duty of protecting the larynx, and accomplishes this purpose very perfectly, after a little time, without the aid afforded by the constriction of the latter, which, I believe, is the more important of the two.

With a properly fitting tube, a healthy epiglottis, and freedom from much inflammation or thickening above the vocal cords, the difficulty of swallowing at first experienced is usually completely overcome in about a week.

In the treatment of chronic stenosis of the larynx in children, the set of croup tubes will do to begin with, but the calibre of these is only sufficient for free respiration in a state of rest, and therefore not large enough to supply the increased demand for oxygen produced by the active exercise that these little patients take, which is not materially different from that of ordinary health. In the beginning, therefore, when it is only possible to pass a small tube through the stricture, it will be necessary to restrict the amount of exercise or even confine the patient to bed in order to avoid dyspnœa.

Unlike the conditions present in croup, with its intense inflammatory infiltration of the mucous membrane, which often leads to spontaneous ulceration, the larynx in these cases, aside from the constriction, is usually normal, and the same danger of injury from pressure does not exist. Much larger tubes, and more nearly cylindrical if required, can therefore be used with perfect safety.

The length of time required for the dilatation of chronic stenosis of the larynx will depend on the degree of constriction, its cause, and duration. In complete occlusion, atrophied muscles and anchylosed joints, the necessary result of suspended function, render such cases the most unfavorable for speedy cure.

Even a very small opening in the larynx, that allows the entrance of some air, which keeps the arytenoids and the muscles that move them in use, gives a better prospect of recovery in a reasonable time.

Cases in which a tracheal cannula has been retained as long as a year or more will usually require dilatation for several months to effect a permanent cure.

Where complete closure of the larynx exists, divulsion should be practiced through the tracheal wound from below, because owing to the gradual inclination of the vocal cords from the circumference towards the centre in this situation, there is no danger of passing the sound or other instrument used anywhere else than in the line of the original opening; while if done from above, through the mouth, there can be no certainty that the point of the instrument is not in one of the ventricles, which it would penetrate with the employment of less force than would be required to pass through the cicatricial tissue uniting the vocal cords.

In the majority of the cases so far treated by myself and others, syphilis, usually in its tertiary form, was the cause of the stenosis.

In two children, one a constriction, the other a complete occlusion, the cause was high tracheotomy for croup. The operation in both of these cases involved at least the subglottic division of the larynx, which is often selected because, being less deeply seated, it is more accessible than the trachea.

In one adult, also, who had worn a tracheal cannula for two years, the opening had been made in the cricothyroid space, and in another immediately below the cricoid cartilage.

The lumen of the trachea is large, while that of the larynx is comparatively small, and, besides the delicate articular and muscular apparatus of the latter is liable to serious injury from the irritation of a cannula if long retained. There is therefore no excuse for laryngotomy or high tracheotomy, except for the removal of a foreign body or neoplasm, and possibly when pressed for time in case of threatened asphyxia, as these operations are undoubtedly the most frequent cause of retained cannulas in croup and other forms of obstruction that recover in a short time.

To insure success in management of chronic stenosis of the larynx, some ingenuity and a great deal of patience and perseverance are necessary in order to overcome the many difficulties encountered. No set of instruments, however complete, will be sufficient for all cases, no two of which are alike, and the construction of tubes adapted to special peculiarities will sometimes be required.

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